EXHIBIT J

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(56) Documents Cited
GB 2264302 A GB 2214515 A
WPI Abstract Accession No 91-026451/04 & JP 2297384A WPI Abstract Accession No 90-144918/19 & JP 2092378A

(58) Field of Search
UK CL (Edition M) C3M MXC, C3V VEM
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(54) Golf balls

(57) A solid golf ball includes a solid core enclosed in a cover. The resin component of the cover consists of 30 to 100% by weight of an ethylene-methacrylic acid-acrylate terpolymer ionomer resin having a flexural modulus of 2,500 - 14,000 psi and a Shore D hardness of 20 - 59 and 70 to 0% by weight of an ethylene-(meth)acrylic acid copolymer ionomer resin having a flexural modulus of 20,000 - 30,000 psi and a Shore D hardness of 56 - 64. The core is made of a rubber composition comprising 100 parts by weight of a base rubber and 0.2 - 1.5 parts by weight of pentachlorothiophenol and/or metal salt thereof and has a distortion of 2.3 - 3.3 mm under a load of 100 kg. The ball is excellent in spin receptivity, burring resistance, and repulsion.

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GOLF BALLS

This specification relates to golf balls. Desirable characteristics of a golf ball are ball control, spin receptivity, durability, repulsion, and flying performance.

Prior Art

Because of their impact durability and cut resistance, ionomer resins in the form of ethylene – (meth)acrylic acid copolymers have been widely used and accepted as the cover material for most two – piece golf balls and some wound golf balls. It is, however, said that golf balls with ionomer resin covers are difficult to give a spin as intended when hit by an iron and thus relatively poor in ball control, probably because the ionomer resins offer a harder feel on hitting and have higher hardness than balata rubber (which is a conventional cover material).

It was thus proposed to use a blend of

soft and hard ionomer resins as the golf ball cover as disclosed in US-A-4,884,814 and JP-A-308577/1989. More particularly, an ionomer resin in the form of an ethylene — (meth)acrylic acid copolymer having a certain spectrum of physical properties is blended with a relatively soft ionomer resin in the form of an ethylene — (meth)acrylic acid — (meth)acrylate terpolymer. While the golf balls using an ionomer resin in the form of an ethylene — (meth)acrylic acid copolymer as the cover suffered from hard hitting feel and difficult ball control, the use of such a blend was effective for achieving significant improvements in these properties.

A golf ball cover of a soft and hard ionomer blend as mentioned above nevertheless has the following problems. The fact that the cover is softer and more receptive to spin on an iron shot indicates an increased frictional force between the club face and the cover. So, balls using a hard core like two — piece golf balls tend to be burred or finely split on the surface since the cover surface can be ablated or scraped by the iron club grooves on an iron shot.

In addition, the ionomer cover itself is low in repulsion due to low hardness, resulting in a substantial loss of ball repulsion.

The general aim herein is the provision of novel and useful golf ball constructions. The preferred aim is to provide a solid golf ball which is satisfactory in feel, spin receptivity, ball control, repulsion, and burring resistance, while maintaining the flying distance inherent to solid golf balls such as two-piece golf balls.

The inventors have found that as compared with the conventional blend of hard and soft ionomer resins, a blend of a mid-hardness ionomer resin (having a hardness intermediate between hard and soft ionomer resins) and a soft ionomer resin or a soft ionomer resin alone experiences significantly less surface damage on an iron shot. Balls with a cover which is more resistant against burring on the surface are

also satisfactory in feel and spin properties. However, the cover as such is soft and thus low repulsive. It is then difficult to utilize this cover in golf balls. Quite unexpectedly, the above-mentioned requirements can be effectively met by combining the cover with a special core. By blending pentachlorothiophenol or a metal salt thereof in base rubber, a more repulsive core is obtained so that the resulting ball provides a satisfactory level of repulsion.

So, one aspect of our proposals is a golf ball comprising a solid core and a cover enclosing the core. The cover is based on a resin component consisting of (1) 30 to 100% by weight of a first ionomer resin in the form of an ethylene-methacrylic acid-acrylate terpolymer of flexural modulus 2,500 to 14,000 psi (17 to 97MPa) and a Shore D hardness of 20 to 59 and (2) 70 to 0% by weight of a second ionomer resin in the form of an ethylene-(meth)acrylic acid copolymer having flexural modulus 20,000 to 30,000 psi (135 to 210 MPa) and a Shore D hardness of 56 to 64. The core is made of a rubber composition comprising 100 parts by weight of a base rubber and 0.2 to 1.5 parts by weight of pentachloro-

thiophenol or a metal salt thereof. Typically it has a distortion of 2.3 to 3.3 mm under a load of 100 kg.

Another aspect is a method of making such a golf ball.

The golf ball has a generally spherical solid core enclosed in a cover. The cover is essentially made of a blend of (1) 30 to 100% by weight, preferably 50 to 90% by weight of a first ionomer resin in the form of an ethylene—methacrylic acid—acrylate terpolymer and (2) 70 to 0% by weight, preferably 50 to 10% by weight of a second ionomer resin in the form of an ethylene—(meth)acrylic acid copolymer. The first ionomer resin in the form of an ethylene—methacrylic acid—acrylate terpolymer has a flexural modulus of 2,500 to 14,000 psi and a Shore D hardness of 20 to 59. Suitable ones are available under the trade names of Himilan® from DuPont-Mitsui Polychemical Co., Ltd. and Surlyn® from E.I. DuPont (as shown in Table 1). The second ionomer resin in the form of an ethylene—(meth)acrylic acid copolymer has a flexural modulus of 20,000 to 30,000 psi and a Shore D hardness of 56 to 64.

Suitable ones are available under the trade name Himilan® as mentioned above, and as shown in Table 2.

Table 1

	Ion	Flexural modulus (psi)	Shore D hardness
Himilan 1855	Zn	13,000	56
Himilan 1856	Na	10,100	58
Surlyn 8120	Na	7,100	39
Surlyn 8320	Na	2,800	25

Table 2

	Ion	Flexural modulus (psi)	Shore D hardness
Himilan 1650	Zn	24,700	60
Himilan 1652	Zn	23,000	57
Himilan 1702	Zn	21,700	62

In addition to the resin component, the resin composition for the cover may contain optional additives, for example, dyestuffs, pigments such as titanium dioxide, zinc oxide, and barium sulfate, UV absorbers, anti-oxidants, and dispersing aids such as metal soaps. The ionomer resins and optional additives are mixed in a conventional mixer such as a closed kneader (e.g., Banbury mixer and

kneader) and an extruder and then molded in a conventional manner.

The preferred core composition comprises the base rubber, metal salt of an unsaturated carboxylic acid, and . peroxide, to which pentachlorothiophenol or metal salt thereof is added as an essential component. The base rubber is preferably cis-1,4-poly-butadiene rubber containing at least 90% of cis-configuration because of its high repulsion. Although another rubber component such as natural rubber and polyisoprene rubber may be blended in the cis-1,4-polybutadiene rubber, it is preferred that the base rubber contains at least 80% by weight of the high cis-1,4-polybutadiene rubber. With less than 80% by weight of high cis-1,4-polybutadiene rubber, the base rubber may not take full advantage of the repulsion thereof. A metal salt of an unsaturated carboxylic acid such as acrylic acid and methacrylic acid may be used as a co-crosslinking agent, preferably in an amount of about 25 to 40 parts by weight per 100 parts by weight of the base rubber. Examples of the metal salt of an unsaturated carboxylic acid

include zinc salts, magnesium salts and calcium salts of acrylic acid or methacrylic acid. Among them, zinc acrylate is most preferred. Suitable peroxides include dicumyl peroxide, t-butylperoxybenzoate, di-t-butylperoxide, and 1,1-bis(t-butylperoxy)-3,3,5-trimethyl-cyclohexane. Preferably the peroxide is blended in an amount of about 0.5 to 3 parts, more preferably 0.8 to 2 parts by weight per 100 parts by weight of the base rubber. Penta-chlorothiophenol and/or its salt is blended in an amount of about 0.2 to 1.5 parts by weight per 100 parts by weight of the base rubber in order that this blend system be enhanced in repulsion. Beyond this range, the rubber composition for the core may be retarded in crosslinking reaction. Examples of the salt include zinc salt of pentachlorothiophenol.

If desired, the rubber composition for the core may contain any additive commonly used in the core of two-piece solid golf balls, for example, zinc oxide, anti-oxidant, and barium sulfate. The core rubber composition may be mixed in a conventional mixer such as a Banbury mixer and kneader and then molded and cured into a

spherical core by hot pressure vulcanization in a conventional manner. The vulcanized composition or core should have a hardness in a specific range. That is, the distortion of the core under a load of 100 kg should be 2.3 to 3.3 mm. With a distortion of less than 2.3 mm, a ball after enclosure in a cover as defined above is hard and gives an unpleasant hitting feel. With a distortion of more than 3.3 mm, the resulting ball is less repulsive.

The golf ball may be constructed and assembled using conventional techniques, for example by molding a solid core from a core material, forming leaf cups from a cover material by a conventional molding technique, and enclosing the core with the leaf cups followed by heat compression molding. Alternatively the solid core is directly covered with a cover material by injection molding.

Desirable thickness of the cover is in the range of 1.4 to 2.5 mm. Typical diameter of the golf ball is 42.67 mm or more and typical weight of the golf ball is 45.93 g or less.

Examples are given below, by way of illustration and not by way of limitation.

A solid core was formed from a rubber composition of the following components.

Component	Parts by weight
cis — 1,4 — polybutadiene rubber (BR01)	100
zinc acrylate	33.5
zinc oxide	10
barium sulfate	9.6
anti — oxidant	0.2
dicumyl peroxide	0.9

The solid core was directly covered by injection molding with a cover material consisting of ionomer resin, titanium dioxide for coloring, and dispersing aids, and having a specific gravity of 0.99. The ionomer resins used were Himilan and Surlyn resins having physical properties as shown in Table 3. They were mixed as shown in Table 4. The cover was surface treated and coated with clear lacquer. The resulting two — piece golf balls were measured

for weight (g), surface hardness (Shore C and D scales), distortion (mm under a load of 100 kg) and initial speed (m/sec.).

The thickness of the cover was 2.0 mm. The diameter of the golf ball was 42.7 mm and the weight of the golf ball was 45.2 g.

Table 3

Designation	Ion type	MER	Elongation (%)	Flexural modulus (psi)	Shore D hardness
Himilan 1706	Zn	0.7	290	47,900	66
Himilan 1577	Zn	5.0	410	36,300	63
Himilan 1650	Zn	1.5	460	24,700	60
Himilan 1652	Zn	5.0	500	23,000	57
Himilan 1855	Zn	1.0	510	13,000	56
Himilan 1856	Na	1.0	530	10,100	58
Surlyn 8120	Na	0.9	660	7,100	39
Surlyn 8320	Na	0.9	770	2,800	25

A burring test was carried out on the balls using a robot machine equipped with three pitching wedges, Eagle PW, Rextar HT305 PW and MSX PW commercially available from Bridgestone Sports Co., Ltd. A ball was hit at three different points, once at each point, by each pitching wedge at a head speed of 37 m/s. The three hit points on the ball were visually

observed and evaluated in accordance with the following criteria.

○: slight, substantially unnoticeable club face mark

△: distinct club face mark, but not feathered on cover surface

×: surface burred and noticeably feathered

The results are also shown in Table 4.

Table 4

	Examples							Comparative Examples				
	1	2	3	4	5	6	7	1	2	3	4	5
Cover resin mix												
Himilan 1706 (Zn)								50		50	25	
Himilan 1557 (Zn)									50			
Himilan 1650 (Zn)	50	50	50	25		30					75	75
Himilan 1652 (Zn)				25	50							
Himilan 1702 (Zn)												
Himilan 1855 (Zn)							50					
Himilan 1856 (Zn)	50						50					
Surlyn 8120 (Na)		50		50	50	70		50	50			25
Surlyn 8320 (Na)			50							50		

Table 4 (Contd.)

		Examples							Comparative Examples				
		1	2	3	4	5	6	7	1	2	3	4	5
Ball properties													
Weight (g)		45.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2
Surface hardness	Shore C		82		79	76							
	Shore D	60	57	49	55	53	51	58	59	58	53	61	59
Distortion (mm)		2.39	2.43	2.57	2.47	2.44	2.52	2.40	2.37	2.38	2.40	2.30	2.36
Initial speed (m/sec.)		77.09	76.83	76.57	76.81	76.59	76.62	76.80	77.22	77.26	76.10	77.15	77.01
Burring test													
Eagle PW		○ or △	○	○	○ or △	○ or △	○	○ or △	× or △	△	×	×	△
Rextar HT305 PW		○ or △	○	○	○ or △	○	○	○	× or △	△	×	×	△
MSX PW		○	○	○	○	○	○	○	△	△	△ or ×	△ or ×	△

It is evident from Table 4 that the covers embodying the new proposals are fully resistant against burring by the iron club face.

Next, cores (of diameter 38.7 mm) were molded from the compositions shown in Table 5 and measured for a distortion (mm) under a load of 100 kg and initial speed (m/sec.). The core initial speed was measured using an initial speed meter of the same type as prescribed by golf ball authorized organization R&A (USGA). The results are also shown in Table 5.

Table 5

	Control Core	Examples				
	1	1	2	3	4	5
Composition						
BR01	100	100	100	100	100	100
Zinc acrylate	33.5	33.5	33.5	33.5	33.5	33.5
Barium sulfate	9.6	9.6	9.6	9.6	9.6	9.6
Zinc oxide	10	10	10	10	10	10
Anti-oxidant	0.2	0.2	0.2	0.2	0.2	0.2
Lenacit V*	—	0.2	0.4	0.6	1.0	1.5
Dicumyl peroxide	0.9	0.9	0.9	0.9	0.9	0.9
Vulcanised core properties						
Distortion (mm)	2.61	2.51	2.62	2.64	2.67	2.71
Initial speed	77.75	78.14	78.29	78.35	78.64	78.54

* zinc salt of pentachlorothiophenol commercially available from Bayer Japan Ltd.

It is evident from Table 5 that the cores embodying the present concepts offer a good initial speed which indicates a good repulsion.

Next, two-piece golf balls were prepared by combining the cover and the core as shown in Table 6. The balls were measured for initial speed by the same procedure as above. The balls were also determined for back spin, stop on the green, and driver flying distance by the following tests. The thickness of the cover was 2.0 mm.

Back spin

Using a swing robot manufactured by True Temper Co., the ball was hit by an iron (pitching wedge) at a head speed of 37 m/s. The spin quantity was measured by taking a photograph of the ball immediately after impact followed by image analysis.

Stop on the green

Using the swing robot, the ball was hit by

a pitching wedge so as to fly directly on the green. The distance between the landing and stop positions, which was the distance the ball covered due to back spin, was measured.

Flying distance

Using the swing robot, the ball was hit by a driver W#1 at a head speed of 45 m/s to measure the flying distance.

The results are shown in Table 6.

Table 6

	Examples			Com-parative No. 1	Commercial 2-piece golf ball
	No. 1	No. 4	No. 4		
Cover resin mix	Himilan 1650/ Surlyn 8120 50/50	Himilan 1650/ Surlyn 8120 50/50	Himilan 1855/ Surlyn 1856 50/50	Himilan 1650/ Surlyn 8120 50/50	Himilan 1706/ Surlyn 1650 50/50
Initial speed (m/s)	77.08	77.30	77.27	76.85	77.10
Back spin (rpm)	9350	9280	9310	9290	8750
Stop on the green (m)	0.0	0.5	0.5	0.5	3.5
Driver flying distance	225.0	224.5	225.5	220.5	225.0

As is evident from Table 6, the golf balls

embodying our concepts were excellent in ball control and flying performance. These golf balls were also good in spin characteristics, burring resistance, and repulsion.

Although some preferred embodiments have been described, many modifications and variations may be made thereto in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practised otherwise than as specifically described.

CLAIMS:

1. A golf ball comprising a solid core and a cover enclosing the core, wherein

said cover is based on a resin component consisting of 30 to 100% by weight of first ionomer resin in the form of ethylene—methacrylic acid—acrylate terpolymer having a flexural modulus of 2,500 to 14,000 psi and a Shore D hardness of 20 to 59, and 70 to 0% by weight of second ionomer resin in the form of ethylene—(meth)acrylic acid copolymer having a flexural modulus of 20,000 to 30,000 psi and a Shore D hardness of 56 to 64, and

said core is made of a rubber composition comprising 100 parts by weight of a base rubber and 0.2 to 1.5 parts by weight of penta—chlorothiophenol and/or metal salt thereof.

2. A golf ball according to claim 1 in which the cover resin component contains 50 to 90wt% of first ionomer resin and 10 to 50wt% of the second ionomer resin.

3. A golf ball according to claim 1 or claim 2 in which the core rubber composition base rubber is at least 80wt% of high-cis 1,4-polybutadiene rubber.

4. A golf ball according to any one of the preceding claims in which the core rubber composition is cured from a composition of the base rubber, a metal salt of an unsaturated carboxylic acid, peroxide and said pentachlorothiophenol and/or salt thereof.

5. A golf ball substantially as described herein with reference to any one of the Examples (but not the Comparative Examples).

Patents Act 1977 Examiner's report to the Comptroller under Section 17 The Search report) -21-	Application number GB 9404469.0
Relevant Technical Fields (i) UK Cl (Ed.M) C3V (VEM); C3M (MXC) (ii) Int Cl (Ed.5) A63B	Search Examiner K MacDONALD Date of completion of Search 20 JUNE 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASES: WPI	Documents considered relevant following a search in respect of Claims :- 1-5

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
Y,P	GB 2264302 A (RAM) 25 August 1993; Claims 1-5	At least Claim 1
Y	GB 2214515 A (SPALDING & EVENFLO) Claims 1, 2, 14	At least Claim 1
Y	WPI Abstract Accession Number 91-026451/04 and JP 2297384 A (BRIDGESTONE) 7 December 1990 (see abstract)	At least Claim 1
Y	WPI Abstract Accession Number 90-144918/19 and JP 2092378 A (BRIDGESTONE) 3 April 1990 (see abstract)	At least Claim 1

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

EXHIBIT K

E. Chan
3-13-97

fee D.C.

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

5/a

In re the Application of

Hisashi YAMAGISHI et al.

Application No: 08/536,049 Group Art Unit: 3304

Filed: September 29, 1995 Examiner: Marlo, G.

For: GOLF BALL

AMENDMENT UNDER 37 C.F.R. 1.115

Assistant Commissioner of Patents
Washington, D.C. 20231

Sir:

This Amendment is responsive to the Office Action of September 4, 1996, for which the Examiner has set a three-month period for response. A Petition and Fee Authorization for a three month extension of time is submitted herewith, thus making the response due on March 4, 1997

Please amend the above-identified case as follows:

IN THE CLAIMS:

1. (Amended) A golf ball comprising a core and a cover wherein said core and said ball has a core hardness and a ball hardness respectively, wherein said core has a distortion of 2.9 to 4.0 mm [core hardness expressed by a distortion of at least 2.2 mm] under a load of 100 kg, the ratio of a core distortion under a load of 100 kg divided by a ball distortion under a load of 100 kg ranges from [said ball has a ball hardness, the core hardness divided by ball hardness ranges from] 1.0 to 1.3, and said cover consists of an ionomer resin as a resin component and has a thickness of 1.3 to 1.8 mm and a Shore D hardness of up to 60.

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multi-layer core as a whole (page 4, lines 6-10). Cover hardness is defined in terms of Shore D hardness. Tables 1-3 provide data for core hardness and cover hardness. Thus, core and cover hardness have different definitions. We have amended claim 1 to clarify the language to reflect this understanding.

The Examiner states that in claim 2, "60°" is not understood for a hardness value. Applicants refer the Examiner to page 4 of the specification, lines 11-16, where Shore D hardness has units of degrees.

Claims 1-3 are rejected under 35 U.S.C. §102(a) and §103 as being obvious over Saito (924), Saito (434), Saito et al, Yabuki et al (608), Yabuki et al (110) and Egashira et al (UK) (hereafter "Saito '924", "Saito '434", "Saito", "Yabuki '608", "Yabuki '110" and "Egashira", respectively).

Applicants respectfully traverse the Examiner's position. The references do not teach or suggest the following claimed features of the present invention: (i) an ionomer resin; (ii) ratio of core/ball distortion under a load of 100 kg; (iii) the combination of the cover thickness and core distortion; and (iv) the improved properties as a consequence, e.g., durability and superior flying distance combined with stop on the green.

Saito '924 discloses a solid golf ball comprising a solid core and a cover:

where the solid core is formed from a composition comprising a polybutadiene containing at least 40% of a cis-1,4-bond and an

unsaturated carboxylic acid and/or a metal salt thereof for causing crosslinking of said polybutadiene and having a deformation of 1.5 to 3.5 mm under a constant load of 100 kg, and the difference in hardness between the center and the periphery of the solid core is less than 10%; and

where the cover is formed from a thermoplastic resin composition comprising 97 to 65% by weight of an ionomer resin and 3 to 35% by weight of a flexible resin selected from the group consisting of polyester elastomers, polyamide elastomer, thermoplastic urethane elastomers, propylene-butadiene copolymers, 1,2-polybutadienes, polybutene-1 and styrene-butadiene block copolymers and mixtures thereof and having a resilience of at least 35%, and having a flexural modulus of 1,500 to 4,500 kg/cm^2 and a thickness of 0.3 to 1.8 mm.

Therefore, the cover of Saito '924 contains as an essential component the flexible resin. On the other hand, the cover of the presently claimed invention consists of an ionomer resin as a resin component. A cover consisting of an ionomer resin has superior durability as compared with a cover composed of a mixture of an ionomer resin and another resin because of compatibility.

Saito '434 discloses a solid golf ball comprising a solid core and a cover enclosing the solid core where:

the solid core contains polybutadiene rubber having more than 40% of cis-1,4 bonds and an unsaturated carboxylic acid and/or a

metal salt thereof to crosslink the polybutadiene rubber and deforms 1.5 to 3.5 mm under a constant load of 100 kg;

the cover is 0.4 to 2.2 mm thick which consists of a 0.1 to 2 mm thick inner layer and a 0.1 to 1.5 mm thick outerlayer enclosing the inner layer, both made of thermoplastic resins, the inner layer having a stress of 20 to 100 kg/cm^2 at 10% elongation (measured according to ASTM 638-86) and having resilience higher than 40% measured by a Dunlop tripsometer (defined in British Standard No. 903) where the outerlayer has a flexural modulus of 2000 to 5000 kg/cm^2, (measured according to ASTM D 790) and a resilience higher than 35% measured by a Dunlop tripsometer.

Therefore, Saito '434 also fails to disclose and teach the present cover consisting of an ionomer resin as a resin component.

Yabuki '608 discloses a two piece golf ball comprising a core and a cover:

where the core has a compression deformation of 3.7 to 4.5 mm caused by applying from 10 kg (of an initial load) to 130 kg (of a final load), the core is prepared from a rubber composition comprising 100 parts by weight of a cis-1,4-polybutadiene rubber and 20 to 30% by weight of a Group IIA or IIB metal salt of (meth)acrylic acid; and

where the cover has a stiffness modulus of 3,700 to 4,500 kg/cm^2 and a thickness of 2.2 to 2.9 mm.

Therefore, Yabuki '608 teaches a cover thickness of 2.2 to 2.9

mm which is considerably thicker than the cover thickness of the presently claimed invention (1.3-1.8 mm). Further, Yabuki '608 fails to teach the ratio of the core distortion/the ball distortion under a load of 100 kg according to the present invention.

Yabuki '110 discloses a two-piece golf ball comprising a core formed from a rubber composition comprising a base rubber, a co-crosslinking agent and an organic peroxide, and a cover covering the core, where the core has the following hardness distribution when measured by a JIS-C hardness meter;

(1) hardness at a center: 58-73

(2) hardness at 5-10 mm from the center: 68-78

(3) hardness at 15 mm from the center: 76-88

(4) surface hardness: 78-88

where in the hardness distribution, hardness (2) is substantially constant being within the above range, of which tolerance is within ± 3 and the other values satisfy the relation of $(1)<(2)<(3)\leq(4)$, a compression deformation of the core is 2.8-3.5 mm when pressurized by an initial load of 10 kg up to a final load of 130 kg and said cover has a thickness of 1.5-1 9 mm.

Therefore, Yabuki '110 also does not teach the present ratio of core distortion/ball distortion under a load of 100 kg.

Egashira (UK) discloses a golf ball comprising a solid core and a cover enclosing the core where:

the cover is based on a resin component consisting of 30 to 100% by weight of first ionomer resin in the form of

ethylene-methacrylic acid-acrylate terpolymer having a flexural modulus of 2,500 to 14,000 psi and a Shore D hardness of 20 to 59, and 70 to 0% by weight of second ionomer resin in the form of ethylene-(meth)acrylic acid copolymer having a flexural modulus of 20,000 to 30,000 psi and a Shore D hardness of 56 to 64, and

the core is made of a rubber composition comprising 100 parts by weight of a base rubber and 0.2 to 1.5 parts by weight of pentachlorothiophenol and/or metal salt thereof.

Egashira also fails to disclose the combination of the cover thickness and the core distortion of the present golf ball. The cover thickness of Egashira is 2.0 mm and the core distortion is 2.51 to 2.71 (see Examples) which do not fall within the presently claimed range.

Furthermore, as the core distortion increases the core becomes softer. The present core distortion of 2.9 to 4.0 mm under a load of 100 kg means that the present core is very soft. Also, the present cover hardness is up to 60 on Shore D and thus is not hard. In general, the combination of a softer core and a softer cover results in a low repulsion, i.e., an inferior flying distance. In the present golf ball, since the cover thickness is 1.3 to 1.8 mm which is thin and the ratio of core distortion/ball distortion is 1.0 to 1.3, a flying distance as well, as stop on the green, are good regardless of the combination of a soft core and cover. This feature of the present invention is not disclosed or taught by Egashira, as well as the other references.

EXHIBIT L

US006679791B2

(12) **United States Patent**
Watanabe

(10) **Patent No.: US 6,679,791 B2**
(45) **Date of Patent: Jan. 20, 2004**

(54) **GOLF BALL**

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(57) **ABSTRACT**

A multi-piece golf ball includes a rubbery elastic core, a cover having a plurality of dimples on the surface thereof, and at least one intermediate layer between the core and the cover. The intermediate layer is composed of a resin material which is harder than the cover. The elastic core has a hardness which gradually increases radially outward from the center to the surface thereof. The center and surface of the elastic core have a hardness difference of at least 18 JIS-C hardness units. This construction and combination of features improve the distance of the ball when struck with a driver, provide the ball with excellent spin characteristics and thus good controllability on approach shots, and gives the ball a good feel on impact, enabling the ball to meet the high expectations of skilled golfers.

27 Claims, 1 Drawing Sheet

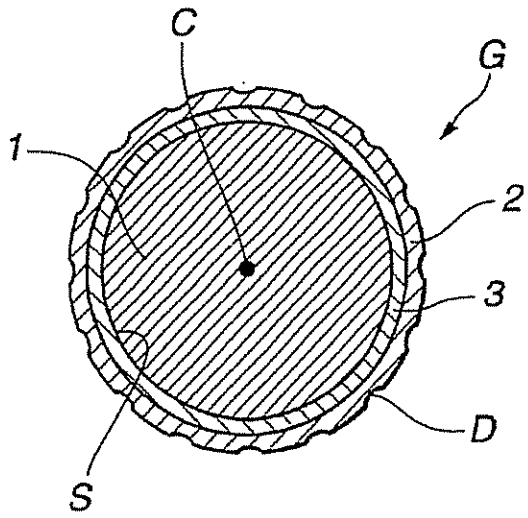
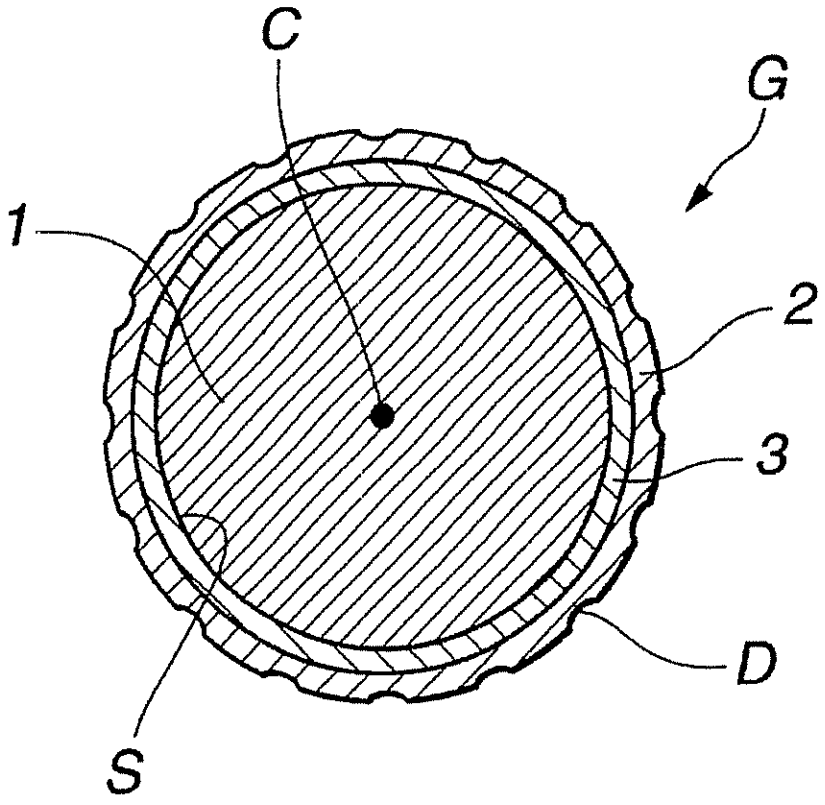


FIG.1



GOLF BALL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a golf ball having a multilayer construction of at least three layers which includes a core, an intermediate layer and a cover. More particularly, the invention relates to a golf ball which has good rebound characteristics and provides an excellent travel distance, controllability and "feel" upon impact with a golf club.

2. Prior Art

In recent years, solid golf balls, with their good flight performance, have consistently won greater general approval than conventional thread-wound golf balls.

Solid golf ball constructions include two-piece balls made of a solid, high-resilience, rubber core enclosed within a relatively thin resin cover, and multi-piece balls having a core, a cover, and also an intermediate layer therebetween whose properties differ somewhat from those of the cover.

As already noted, because of their good flight performance (i.e, long travel distance), solid golf balls of these types are widely favored by both amateur and professional golfers. Yet, there remains a desire among golfers for even better flight performance.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a golf ball having a multilayer construction of three or more layers that is endowed with improved distance without diminishing the controllability and feel that are so important to skilled golfers.

Accordingly, the invention provides a golf ball comprising a rubbery elastic core having a center and a radially outer surface, a cover having a plurality of dimples on the surface thereof, and at least one intermediate layer situated between the core and the cover. The intermediate layer is composed of a resin material which is harder than the cover. The elastic core has a hardness which gradually increases radially outward from the center to the surface thereof, and a difference in JIS-C hardness of at least 18 between the center and the surface.

Preferably, the JIS-C hardness at the center of the core is 50 to 65, and the JIS-C hardness at the surface of the core is 70 to 90. The core typically undergoes a deformation of 3.0 to 5.0 mm when the load applied thereto is increased from an initial load of 98 N (10 kgf) to a final load of 1,275 N (130 kgf).

BRIEF DESCRIPTION OF THE DRAWING

The objects, features and advantages of the invention will become more apparent from the following detailed description, taken in conjunction with the accompanying diagram.

The only FIGURE, FIG. 1 is a sectional view showing a golf ball according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, the golf ball G of the present invention has a construction composed of at least three layers, commonly known as a "multi-piece construction," which include a rubbery elastic core 1, a cover 2 that is

generally made of a resin material and has a plurality of dimples D on the surface thereof, and one or more intermediate layer 3 between the core 1 and the cover 2, all situated in a concentric fashion. The illustrated embodiment has a single intermediate layer. The intermediate layer 3 is made of a resin material which is harder than the cover 2. The core 1 having a center C and a surface S at its radially outer extremity has a JIS-C hardness which gradually increases radially outward from the center C to the surface S. The core 1 is formed so as to have a specific hardness difference between the surface S and the center C.

The inventive golf ball includes a hard intermediate layer disposed between the core, which has an optimized hardness profile, and the cover which is softer than the intermediate layer. This construction provides the ball with an excellent "feel," holds down spin when the ball is struck with a driver, and increases the distance traveled, in part by creating a trajectory which does not describe a high arc when traveling into a headwind. At the same time, it increases the amount of spin on approach shots taken with a club having a large loft angle, thus imparting the excellent control desired in particular by professionals and other skilled golfers.

In the golf ball of the present invention, the core may be made from a known core material which is prepared by blending, for example, a base rubber, the metal salt of an unsaturated carboxylic acid, and an organic peroxide.

The base rubber is preferably polybutadiene. The use of 1,4-polybutadiene, and especially one having a cis structure of at least 40%, is recommended. In addition to the polybutadiene, the base rubber may also include other rubbers such as natural rubber, polyisoprene rubber and styrene-butadiene rubber, if necessary.

Examples of suitable metal salts of unsaturated carboxylic acids include zinc dimethacrylate and zinc diacrylate. Zinc diacrylate is especially preferred for achieving a high rebound energy. It is advantageous to include such unsaturated carboxylic acids in an amount of at least 15 parts by weight, and preferably at least 20 parts by weight, but not more than 50 parts by weight, and preferably not more than 45 parts by weight, per 100 parts by weight of the base rubber.

Examples of suitable organic peroxides include 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, dicumyl peroxide, di-(t-butylperoxy)-m-diisopropylbenzene and 2,5-dimethyl-2,5-di-t-butylperoxyhexane. It is advantageous to include such peroxides in an amount of at least 0.1 part by weight, and preferably at least 0.5 part by weight, but not more than 5 parts by weight, and preferably not more than 2 parts by weight, per 100 parts by weight of the base rubber.

To impart good rebound characteristics, it is advisable to include a suitable compounding ingredient such as a thiophenol, thionaphthol, halogenated thiophenol or metal salt thereof in the core material. Specific examples of such compounding ingredients that may be used include pentachlorothiophenol, pentafluorothiophenol, pentabromothiophenol, p-chlorothiophenol and the zinc salt of pentachlorothiophenol. The zinc salt of pentachloro-thiophenol is especially preferred. Such a compounding ingredient is typically included in an amount of at least 0.4 part by weight, and preferably at least 0.6 part by weight, but not more than 2.0 parts by weight, and preferably not more than 1.2 parts by weight, per 100 parts by weight of the base rubber. Too much of this ingredient tends to lower the core hardness, which can adversely impact the feel of the ball when hit as well as its durability (cracking resistance), whereas too little may lower the rebound energy of the core, making it impossible for the ball to achieve a sufficient carry.

If necessary, the core material may include also various additives such as inorganic fillers and antioxidants. Illustrative examples of such additives include zinc oxide, barium sulfate and calcium carbonate.

The core may be fabricated from the above core material by using a conventional process to blend the various ingredients and mold the resulting mixture. For example, the constituent ingredients may be blended in a suitable apparatus such as a Banbury mixer or a kneader to form a "slug," which is then placed in a mold where it is vulcanized at a temperature of generally at least 150° C., and preferably at least 160° C., but generally not more than 190° C., and preferably not more than 180° C. The period of vulcanization is generally at least 8 minutes, and preferably at least 12 minutes, but generally not more than 20 minutes, and preferably not more than 16 minutes.

The weight and diameter of the core may be suitably adjusted according to such factors as the constituent materials and thickness of the intermediate layer and the cover, which are described subsequently. It is recommended that the core generally have a weight of at least 23 g, and preferably at least 30 g, but not more than 37 g, and preferably not more than 35 g. It is also recommended that the core generally have a diameter of at least 33 mm, and preferably at least 36 mm, but not more than 39 mm, and preferably not more than 38 mm.

It is critical for the core to have an optimized hardness profile in which the hardness gradually increases radially outward from the center toward the outside edge or surface of the core. That is, the core has a higher hardness at the surface than at the center.

The core center and surface must have a difference between their respective measured JIS-C hardnesses of at least 18, preferably at least 20, and most preferably at least 22 units. This difference in hardness within the core gives the ball a low spin when hit with a driver (number 1 wood), enabling it to travel well and thus attain a good total distance. Too small a difference in JIS-C hardness between the relatively soft center and the relatively hard surface of the core allows the ball to take on too much spin when hit with a driver, so that it does not travel well and has a short run after it lands on the ground. This makes it impossible to achieve the desired distance. It is recommended that the upper limit in the hardness difference be at most 30, preferably 27 or less, and most preferably 25 units or less.

Specifically, the core at the center typically has a JIS-C hardness of at least 50, and preferably at least 55, but not more than 65, and preferably not more than 62. The core at the surface typically has a JIS-C hardness of at least 70, and preferably at least 75, but not more than 90, and preferably not more than 85. Too low a JIS-C hardness at the core center may deaden the feel and fail to achieve the desired rebound energy, whereas a hardness that is too high may result in an excessively hard feel when the ball is hit. Similarly, too low a JIS-C hardness at the core surface may deaden the feel of the ball when hit, while too high a hardness may result in too hard a feel.

Preferably the core of the inventive golf ball has a deformation of at least 3.0 mm, and preferably at least 3.3 mm, but not more than 5.0 mm, and preferably not more than 4.5 mm, when the load applied thereto is increased from an initial load of 98 N (10 kgf) to a final load of 1,275 N (130 kgf). Too small a deformation may increase the spin when the ball is hit with a driver, preventing the desired travel from being achieved, and may also give the ball too hard a feel. On the other hand, too much deformation may deaden the feel and fail to achieve the necessary rebound energy.

Since the core has a hardness gradually increasing radially outward from the center to the surface thereof and an optimized difference in hardness between the center and the surface where the core is hardest, the inventive golf ball having the above-described core functions to suppress the generation of excessive spin when it is hit with a driver, effectively increasing the run after it lands on the ground, and thus travelling a longer total distance.

The intermediate layer 3 of the inventive golf ball is an essential layer which is situated between the core 1 and the cover 2 of the ball G, as shown in FIG. 1, and is made of a resin material that is harder than the cover material. Even if the core and cover are within the scope of the present invention, a golf ball lacking the adequate intermediate layer prescribed by the present invention fails to attained the objects of the invention since it cannot adequately suppress spin when hit with a driver, making it impossible to achieve a longer travel distance, and gives a poor feel when hit.

The intermediate layer may be made using a known cover material, illustrative examples of which include an ionomer resin, either by itself or in admixture with a polyester, polyurethane, polyamide, polyolefin or polystyrene thermoplastic elastomer. The use of an ionomer resin by itself is especially preferred, although another thermoplastic resin may be used provided the resin material for the intermediate layer has a greater hardness than the cover. As with the cover material described below, pigments and various other additives may be included in the intermediate material.

The intermediate layer can be formed over the surface of the core using a known process, preferably an injection molding process. For example, once the core is placed within a mold, the intermediate layer material is injection molded over the core in a conventional manner.

The intermediate layer must have a greater hardness than the cover, which is described below. If the intermediate layer has a hardness which is the same as or lower than that of the cover, spin is not adequately suppressed when the ball is hit with a driver, in addition to which the ball has a lower rebound energy, preventing the anticipated total distance from being achieved. It is generally advantageous for the intermediate layer and the cover to have a Shore D hardness difference of at least 2, and preferably at least 5 units, but not more than 20, and preferably not more than 15 units.

It is recommended that the intermediate layer itself have a Shore D hardness of generally at least 50, and preferably at least 55, but not more than 67, and preferably not more than 65.

As already noted, the intermediate layer situated between the core and the cover in the golf ball of the invention has a greater hardness than the cover. The hardnesses of the intermediate layer and the core, when compared using the same hardness scale (i.e., JIS-C hardness or Shore D hardness), are preferably such that the intermediate layer has a greater hardness than the surface of the core. The JIS-C hardness difference between the intermediate layer and the core surface is preferably at least 2, and more preferably at least 6 units, but not more than 22, and more preferably not more than 18 units.

It is recommended that the intermediate layer have a thickness which is generally at least 0.5 mm, but not more than 3 mm, and especially not more than 2 mm. In cases where there are two or more intermediate layers, it is advisable to set the overall thickness of the intermediate layers within the above range.

If the golf ball has two or more intermediate layers situated between the core and the cover, the above-described

hardness relationship must be maintained between the cover and the outer intermediate layer which is in close contact with the cover.

The cover of the golf ball is formed of a material which is softer than the intermediate layer material. Examples of suitable cover materials include ionomer resins and polyurethane thermoplastic elastomers which are softer than the intermediate layer material. The use of an ionomer resin is especially preferred.

It is advantageous for the cover to have a Shore D hardness of generally at least 45, and especially at least 48, but not more than 60, and especially not more than 58. A hardness value that is too low may result in increased spin and an inability to achieve the required total distance. On the other hand, a hardness value that is too high may adversely impact the controllability of shots taken with an iron club having a large loft angle, and approach shots.

A conventional process may be used to form the cover. It is especially preferable to use an injection molding process in which a solid core over which an intermediate layer has been formed is placed within a mold, and the cover material is injection molded over the intermediate layer.

It is recommended that the cover generally have a thickness of at least 0.6 mm, and preferably at least 1.0 mm, but not more than 2.1 mm, and preferably not more than 1.8 mm. Too thin a cover may lower the durability of the ball, whereas a cover that is too thick may lower the ball's rebound energy.

Since the golf ball of the invention has an optimized balance in hardness among the various layers as described above, the ball is endowed with an excellent rebound energy, distance performance, feel, controllability and spin characteristics.

For competition play, the golf ball of the invention may be formed so as to have a diameter and weight which conform with the Rules of Golf. That is, the ball may have a diameter of not less than 42.67 mm and a weight of not greater than 45.93 g.

The inventive golf ball provides increased distance when hit with a driver. On approach shots, the ball has excellent spin characteristics to ensure control as desired. Moreover, it has a good feel on impact. This combination of qualities enables the ball to satisfy the high expectations of skilled golfers in particular.

EXAMPLES

Examples of the invention and comparative examples are given below by way of illustration, and are not intended to limit the invention.

Examples 1-3 and Comparative Examples 1-5

To ascertain the flight characteristics and feel of golf balls according to one embodiment of the invention, golf balls with different hardnesses at the center and surface of the core were produced in Examples 1, 2 and 3. A number of additional examples were carried out for the purpose of comparison. The golf balls produced in Comparative Example 1 had cores with a small or flat hardness profile. The balls produced in Comparative Example 2 had cores with a noticeable, yet gradual, hardness profile. The balls produced in Comparative Example 3 had a core with a distinct hardness profile, but had an intermediate layer that was softer than the cover. The balls produced in Comparative Examples 4 and 5 similarly had cores with distinct hardness profiles, but lacked an intermediate layer. Comparative tests were conducted on these various balls.

The balls were all given the same arrangement of dimples on the surface of the cover. Namely, each ball had a total of 432 dimples of three types formed on the cover in an icosahedral arrangement.

Tables 1 and 2 below show the characteristics of the cover and intermediate layer in the ball samples in each example. Table 3 gives the characteristics of the core in the same balls, and Table 4 presents the test results obtained for each type of ball.

TABLE 1

		Example			Comparative Example				
		1	2	3	1	2	3	4	5
Cover	Material	a	a	a	a	a	b	a	a
	Thickness (mm)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Hardness (Shore D)	55	55	55	55	55	65	55	55
Intermediate layer	Material	b	b	b	b	b	a	—	—
	Thickness (mm)	1.5	1.5	1.5	1.5	1.5	1.5	—	—
	Hardness (Shore D)	65	65	65	65	65	55	—	—

TABLE 2

	Cover, intermediate layer	a	b
Composition (parts by weight)	Himilan AM7317 (Zn)[1]		50
	Himilan 1650 (Zn)[2]	50	
	Himilan AM7318 (Na)[3]		50
	Surlyn 8120 (Na)[4]	50	
	Titanium oxide	5	5
Hardness	Shore D hardness	55	65
	JIS-C hardness	80	94

[1]A zinc ionomer resin having an acid content of 18% made by DuPont-Mitsui Polychemicals Co., Ltd.
[2]A zinc ionomer resin made by DuPont-Mitsui Polychemicals Co., Ltd.
[3]A sodium ionomer resin having an acid content of 18% made by DuPont-Mitsui Polychemicals Co., Ltd.
[4]A sodium ionomer resin made by E. I. DuPont de Nemours and Co.

TABLE 3

			Example			Comparative Example				
			1	2	3	1	2	3	4	5
Core	Composition (pbw)	1,4-cis-Polybutadiene	100	100	100	100	100	100	100	100
		Zinc diacrylate	41.0	38.0	35.0	28.0	27.8	38.0	32.1	28.4
		Peroxide (1)[1]	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
		Peroxide (2)[2]	0.8	0.8	0.8	0.6	0.6	0.8	0.8	0.8
		Sulfur[3]	0.1	0.1	0.1	0	0	0.1	0.1	0.1
		Antioxidant[4]	0	0	0	0.2	0.2	0	0	0
		Barium sulfate	24.1	25.2	26.4	29.8	29.9	25.2	12.8	14.4
		Zinc oxide	5	5	5	5	5	5	5	5

TABLE 3-continued

			Example			Comparative Example				
			1	2	3	1	2	3	4	5
	Zinc salt of pentachlorothiophenol		1	1	1	0.2	0.2	1	1	1
Vulcanization conditions	Primary	Temperature (° C.)	175	175	175	140	155	175	175	175
		Time (min)	15	15	15	30	15	15	15	15
	Secondary	Temperature (° C.)	—	—	—	165	—	—	—	—
		Time (min)	—	—	—	15	—	—	—	—
Hardness	Surface (JIS-C hardness)		85	83	78	76	76	83	87	80
	Center (JIS-C hardness)		61	59	55	72	60	59	63	56
	JIS-C hardness difference		24	24	23	4	16	24	24	24
Deformation under loading (mm)[5]			3.4	3.8	4.1	3.3	3.4	3.8	3.4	4.1

[1]Dicumyl peroxide, produced by NOF Corporation under the trade name Percumyl D.
[2]1,1-Bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, produced by NOF Corporation under the trade name Perhexa 3M-40.
[3]Zinc white-containing sulfur, produced by Tsurumi Chemical Industry Co., Ltd.
[4]Noemek NS-6, produced by Ouchi Shinko Chemical Industrial Co., Ltd.
[5]Deformation under loading from an initial load of 98 N to a final load of 1,275 N

TABLE 4

		Example			Comparative Example				
		1	2	3	1	2	3	4	5
Flight[1]	Carry (m)	233.0	232.2	231.1	233.2	232.1	232.5	231.8	229.5
	Total distance (m)	241.2	243.8	244.9	238.5	239.9	245.5	238.3	241.1
	Spin (rpm)	2805	2745	2700	2910	2855	2550	2952	2847
	Rating	good	good	good	poor	poor	good	poor	fair
Approach[2]	Spin (rpm)	5833	5821	5811	5849	5830	4100	5870	5832
	Rating	good	good	good	good	good	poor	good	good
Feel[3]	When hit with driver	good	good	good	good	good	good	good	poor
	When hit with putter	good	good	good	good	good	poor	good	good

[1]Flight was rated as follows, based on distance measured when ball was hit at a head speed of 50 m/s by a driver mounted on a swing robot.
Good: Total distance at least 241 m
Fair: Total distance at least 241 m, but carry less than 230 m
Poor: Total distance 240 m or less
[2]Approach was rated as follows, based on spin rate measured when ball was hit at a head speed of 19 m/s by a sand wedge mounted on a swing robot.
Good: Good spin (at least 5,500 rpm)
Poor: Inadequate spin (less than 4,500 rpm)
[3]Average sensory evaluations for five professional golfers:
Good: Feel was appropriate and good.
Poor: Feel was too hard or too soft.

As is apparent from the results in Table 4, the golf balls according to the invention all showed a good balance of distance, controllability on approach shots, and feel.

By contrast, the golf balls produced in the comparative examples each had drawbacks. In Comparative Examples 1 and 2, the hardness difference between the surface and center of the core was less than 18, resulting in much spin and a poor distance when the ball was hit with a driver. In Comparative Example 3, the cover was harder than the intermediate layer, and had an excessively high hardness. As a result, the amount of spin on approach shots was low and controllability was poor. In addition, the feel when hit with a putter was poor. The golf balls produced in Comparative Example 4 were two-piece balls which lacked between the cover and the core an intermediate layer of greater hardness than the cover. These balls had a lot of spin when hit with a driver, and thus a poor distance. In the golf balls produced in Comparative Example 5, the core hardness was lowered to reduce the high spin rate on impact with a driver in Comparative Example 4, but the resulting feel on impact with a driver was too soft.

Japanese Patent Application No. 2000-190640 is incorporated herein by reference.

Although some preferred embodiments have been described, many modifications and variations may be made thereto in light of the above teachings. It is therefore to be understood that the invention may be practiced otherwise than as specifically described without departing from the scope of the appended claims.

What is claimed is:

1. A golf ball comprising a rubbery elastic core having a center and a radially outer surface, a cover having a plurality of dimples on the surface thereof, and at least one intermediate layer situated between the core and the cover; wherein

said intermediate layer is composed of a resin material which is harder than the cover and has a greater hardness than the surface of the elastic core when compared using the same hardness scale, and

said elastic core has a hardness which gradually increases radially outward from the center to the surface thereof, and a difference in JIS-C hardness of at least 22 between the center and the surface.

2. The golf ball of claim 1, wherein said core at the center has a JIS-C hardness of 50 to 65, and at the surface a JIS-C hardness of 70 to 90.

3. The golf ball of claim 1, wherein said core undergoes a deformation of 3.0 to 5.0 mm when the load applied

thereto is increased from an initial load of 98 N (10 kgf) to a final load of 1,275 N (130 kgf).

4. The golf ball of claim 1, wherein the difference in JIS-C hardness between the center of the elastic core and the surface thereof is 22 to 30 units.

5. The golf ball of claim 1, wherein the intermediate layer has a Shore D hardness of 50 to 67.

6. The golf ball of claim 1, wherein the JIS-C hardness difference between said intermediate layer and said core surface is 2 to 22 units.

7. The golf ball of claim 1, wherein the cover has a Shore D hardness of 45 to 60.

8. The golf ball of claim 1, wherein the golf ball has two or more intermediate layers situated between the core and the cover, and said hardness relationship is maintained between the cover and the outer intermediate layer which is in close contact with the cover.

9. The golf ball of claim 1, wherein the core is formed of rubber as a base and the cover is formed of materials including ionomer resins and polyurethane thermoplastic elastomers.

10. The golf ball of claim 1, wherein said elastic core is formed of rubber as the base material comprising an ingredient selected from a group consisting of thiophenol, thionaphthol, halogenated thiophenol and metal salt thereof.

11. The golf ball of claim 1, wherein said elastic core is formed of rubber as the base material comprising an ingredient selected from a group consisting of pentachlorothiophenol, pentafluorothiophenol, pentabromothiophenol, p-chlorothiophenol and the zinc salt of pentachlorothiophenol.

12. The golf ball of claim 1, wherein said elastic core is formed of rubber as the base material comprising an ingredient of zinc salt of pentachlorothiophenol added in an amount of 0.4 to 2.0 parts by weight, to per 100 parts by weight of the base rubber.

13. A golf ball comprising a rubbery elastic core having a center and a radially outer surface, a cover having a plurality of dimples on the surface thereof, and at least one intermediate layer situated between the core and the cover; wherein

said intermediate layer is composed of a resin material which is harder than the cover, and has a greater hardness than the surface of the elastic core when compared using the same JIS-C hardness scale, and

said elastic core has a hardness at the center and a hardness at the surface thereof which is greater than the hardness at the center thereof, and a difference in JIS-C hardness of at least 22 between the center and the surface.

14. The golf ball of claim 13, wherein said core at the center has a JIS-C hardness of 50 to 65, and at the surface a JIS-C hardness of 70 to 90.

15. The golf ball of claim 13, wherein the difference in JIS-C hardness between the center of the elastic core and the surface thereof is 22 to 30 units.

16. The golf ball of claim 13, wherein the intermediate layer has a Shore D hardness of 50 to 67.

17. The golf ball of claim 12, wherein the JIS-C hardness difference between said intermediate layer and said core surface is 2 to 22 units.

18. The golf ball of claim 12, wherein the cover has a Shore D hardness of 45 to 60.

19. The golf ball of claim 12, wherein the golf ball has two or more intermediate layers situated between the core and the cover, and said hardness relationship is maintained between the cover and the outer intermediate layer which is in close contact with the cover.

20. The golf ball of claim 12, wherein the core is formed of rubber as a base and the cover is formed of materials including ionomer resins and polyurethane thermoplastic elastomers.

21. The golf ball of claim 13, wherein said elastic core is formed of rubber as the base material comprising an ingredient selected from a group consisting of thiophenol, thionaphthol, halogenated thiophenol and metal salt thereof.

22. The golf ball of claim 13, wherein said elastic core is formed of rubber as the base material comprising an ingredient selected from a group consisting of pentachlorothiophenol, pentafluorothiophenol, pentabromothiophenol, p-chlorothiophenol and the zinc salt of pentafluorothiophenol.

23. The golf ball of claim 13, wherein said elastic core is formed of rubber as the base material comprising an ingredient of zinc salt of pentachlorothiophenol added in an amount of 0.4 to 2.0 parts by weight, to per 100 parts by weight of the base rubber.

24. A golf ball comprising a rubbery elastic core having a center and a radially outer surface, a cover having a plurality of dimples on the surface thereof, and at least one intermediate layer situated between the core and the cover; wherein

said intermediate layer is composed of a resin material which is harder than the cover having a Shore D hardness of 45 to 58 and has a greater hardness than the surface of the elastic core when compared using the same hardness scale, and

said elastic core has a hardness at the center and a hardness at the surface thereof which is greater than the hardness at the center thereof, and a difference in JIS-C hardness of at least 22 between the center and the surface.

25. The golf ball of claim 24, wherein said elastic core is formed of rubber as the base material comprising an ingredient selected from a group consisting of thiophenol, thionaphthol, halogenated thiophenol and metal salt thereof.

26. The golf ball of claim 24, wherein said elastic core is formed of rubber as the base material comprising an ingredient selected from a group consisting of pentachlorothiophenol, pentafluorothiophenol, pentabromothiophenol, p-chlorothiophenol and the zinc salt of pentachlorothiophenol.

27. The golf ball of claim 24, wherein said elastic core is formed of rubber as the base material comprising an ingredient of zinc salt of pentachlorothiophenol added in an amount of 0.4 to 2.0 parts by weight, to per 100 parts by weight of the base rubber.

* * * * *

EXHIBIT M

JIS

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS K 6253 : 1997

Hardness testing methods for rubber, vulcanized or thermoplastic

ICS 83.060

Descriptors : vulcanized rubber, vulcanized materials, hardness testing, mechanical testing, hardness, mechanical properties of materials

Reference number : JIS K 6253 : 1997 (E)

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law:

Date of Establishment: 1993-02-01

Date of Revision: 1997-04-20

Date of Public Notice in Official Gazette: 1997-04-21

Investigated by: Japanese Industrial Standards Committee

Divisional Council on Chemical

JIS K 6253:1997, First English edition published in 1998-12

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

In the event of any doubts arising as to the contents, the original JIS is to be the final authority.

Hardness testing methods for rubber, vulcanized or thermoplastic

Introduction This Japanese Industrial Standard has been prepared on the basis of the 3rd edition of ISO 48, *Rubber, vulcanized or thermoplastic—Determination of hardness (hardness between 10 IRHD and 100 IRHD)* published in 1994, and the 1st edition of **ISO 7619**, *Rubber—Determination of indentation hardness by means of pocket hardness meters* published in 1986, without any modification in technical contents. However, "Type E of spring type (durometer hardness)" which is not specified in the corresponding International Standards are added in this Standard.

1 Scope This Japanese Industrial Standard specifies the testing methods to measure hardness of vulcanized rubber and thermoplastic rubber (hereafter referred to as "vulcanized rubber").

Remarks 1 The standards cited in this Standard are listed as follows.

JIS K 6200 *Glossary of terms used in rubber industry*

JIS K 6250 *General rules of physical testing methods for rubber, vulcanized or thermoplastic*

JIS Z 8401 *Rules for rounding off of numerical values*

2 The International Standards corresponding to this Standard are listed as follows.

ISO 48 : 1994 *Rubber, vulcanized or thermoplastic—Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 7619 : 1986 *Rubber—Determination of indentation hardness by means of pocket hardness meters*

3 The units and numerical values given in { } in this Standard are based on traditional units, and are appended for informative reference.

2 Definitions For the purposes of this Standard, the definitions given in **JIS K 6200** and **JIS K 6250**, and the following definitions apply.

(1) **international rubber hardness degree** Hardness which can be obtained through conversion into international rubber hardness degree (IRHD)(1) using the depth of indentation by a plunger when the plunger, with a ball-type lower end, is vertically impressed on the surface of a test piece with specified indenting force.

A hardness scale is chosen so that "0" represents the hardness of material having a Young's modulus of zero and "100" represents the hardness of a material of infinite Young's modulus, and the following conditions are fulfilled over most of normal range of hardness.

(a) One international rubber hardness degree always represents approximately the same proportionate difference in the Young's modulus.

(b) For highly elastic rubber, the scales of international rubber hardness degree and that of type A durometer are comparable.

Note (1) IRHD International Rubber Hardness Degree

(2) **durometer hardness** The hardness given by the testing apparatus (durometer) which reads the indentation depth made by a specifically shaped indentor when it is impressed on the surface of a test piece via a spring.

(3) **IRHD pocket hardness** The hardness given by a portable pocket testing apparatus (IRHD pocket hardness meter) by which international rubber hardness degree can be conveniently obtained owing to reading the indented depth made by an indentor, with a ball-type lower end, when it impressed on the surface of a test piece via a spring.

(4) **standard hardness** The hardness obtained using the specified procedures on test pieces whose shape and dimensions satisfy the specifications, when carrying out each test.

(5) **apparent hardness** The hardness obtained either using other procedures than the specified, or on the test piece whose shape and dimensions do not satisfy the specification, when carrying out each test.

3 Type of test

3.1 Outline of hardness test There are many types of testing methods for hardness test depending on the principle of hardness measurement, range of hardness measurement, kind of testing apparatus and so on, and they are classified into standard hardness and apparent hardness by shape or dimensions of a test piece. The outline of classifying is shown in Table 1.

Table 1 Outline of hardness tests

Principle of measurement	Range of hardness measurement	Type of testing apparatus	Testing method	Test condition for standard hardness		
				Shape	Thickness mm	Minimum distance from the edge of sample mm
Constant-force type (international rubber hardness degree)	For high hardness (85 to 100 IRHD)	Normal size international rubber hardness meter	H method	Both upper and lower surfaces are smooth and parallel each other.	8.0 min.	9.0
					10.0 max.	10.0
	For normal hardness (30 to 95 IRHD)	Normal size international rubber hardness meter	N method		8.0 min.	9.0
					10.0 max.	10.0
		Microsize international rubber hardness meter	M method		1.5 min.	2.0
					2.5 max.	
	For low hardness (10 to 35 IRHD)	Normal size international rubber hardness meter	L method		10.0 min.	10.0
					15.0 max.	11.5
Spring type (durometer hardness)	For high hardness (A90 or more)	Type D durometer			6.0 or more	12.0
	For normal hardness (A10 to 90)	Type A durometer			6.0 or more	12.0
	For low hardness (A20 or less)	Type E durometer			10.0 or more	12.0
Spring type (IRHD pocket hardness)	For normal hardness (30 to 95 IRHD)	IRHD pocket hardness meter	P method		6.0 or more	12.0

EXHIBIT N

Oxford English Dictionary

Tour: The *OED* goes online

About the *OED*

Before we embark on the tour of *OED Online*, a few words about the *Oxford English Dictionary* itself.

The First Edition began publication in 1884 under the editorship of James Murray, and was completed in 1928. Supplements appeared in 1933, and again between 1972 and 1986. In 1989 the Second Edition appeared, amalgamating the First Edition and the later supplementary material, and adding about 5,000 new entries, and that edition forms the basis for *OED Online*.

In 1993 and 1997 there followed a further three volumes of supplementary material, known as Additions, and these are also included in *OED Online*. Now, for the first time, the whole *OED* is being updated, and the growing set of new and revised entries representing the latest progress towards a new edition will be available online.

According to The Times, the *Oxford English Dictionary* is "the ultimate authority on the English language as well as a history of English speech and thought from its infancy to the present day". It is a unique source of scholarly information on the meaning, history and pronunciation of words both past and present.

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- provides authoritative definitions of over 500,000 words
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- uses the International Phonetic Alphabet to show pronunciation

These features make *OED Online* the most comprehensive and up-to-date reference work of its kind for any language.

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OXFORD
UNIVERSITY PRESS

gradual, *a.*

SECOND EDITION 1989

('grædjuːəl) Also 6 **-ale**, 7 **-all**. [ad. med.L. *graduāl-is*, f. *gradu-s* step. Cf. F. *graduel*.]

†**1.** Of or pertaining to degree; only in ***gradual difference*** = difference in degree. *Obs.*

> **a1652** J. SMITH *Sel. Disc.* VI. ii. (1821) 190 Besides this gradual difference between Moses and the prophets, there is [etc.]. **1651** BAXTER *Saints' Rest* III. xi. §12 A Moral specifical difference is usually founded in a Natural Gradual difference. **1658** —— *Saving Faith* §2. 15 The difference is only gradual, and not specifical.

†**b.** *Mus.* ***gradual tone*** = DEGREE 11 a. *Obs.*

> **1665** C. SIMPSON *Princ. Pract. Musick* 3 All Musick..is formed of Seven Gradual Tones, or Degrees of Sound.

†**2.** *Mus.* Corresponding to the degrees of the natural scale; giving the 'natural' notes. *Obs.*

> **1694** W. HOLDER *Harmony* (1731) 118 The Breves representing the Tones of the broad Gradual Keys of an Organ; the Semibreves representing the narrow Upper Keys.

†**3.** Arranged in, or admitting of, degrees or gradation. *Obs.*

> **1541** R. COPLAND *Guydon's Quest. Chirurg.* Gijb, And in both the endes of y^e^ same ben pyttes receyuynge the roundnesses, Towarde the elbowe ben receyued y^e^ roundnesses graduales of the adiutory [L. *rotunditates gradatas adiutorii*]. **1641** J. JACKSON *True Evang. T.* III. 168 A graduall expression, growing up to the height of its emphasis by foure steps. **1667** MILTON *P.L.* v. 483 Flowers and their fruit, Man's nourishment, by gradual scale sublimed, To vital spirits aspire. **1677** HALE *Prim. Orig. Man.* 129 Moral Evidence is gradual, according to the variety of circumstances. **1712** STEELE *Spect.* No. 270 ¶1 So great an Assembly of

Ladies placed in gradual Rows.

4. Of a process: Taking place by degrees; advancing step by step; slowly progressive. Of a slope: Gentle, not steep or abrupt.

1692 LOCKE *Educ.* §184 By a gradual Progress from the plainest and easiest Historians, he may at last come to read the most difficult and sublime of the Latin Authours. **1701** GREW *Cosm. Sacra* II. viii. 80 The Transition from Humane into Perfect Mind, is made by a Gradual Ascent. **1736** BUTLER *Anal.* I. iii. Wks. 1874 I. 65 The complete success of virtue, as of reason, cannot..be otherwise than gradual. **1781** GIBBON *Decl. & F.* xxix. III. 105 The gradual discovery of the weakness of Arcadius and Honorius. **1821** KEATS *Isabella* xxxii, Isabel By gradual decay from beauty fell. **1840** TANNER *Canals & Rail Roads U.S.* 73 The ascents and descents of the summits are very gradual, not exceeding 30 feet per mile. **1844** EMERSON *Lect., New Eng. Ref.* Wks. (Bohn) I. 260 A gradual withdrawal of tender consciences from the social organizations. **1854** H. MILLER *Sch. & Schm.* xxiv. (1860) 269/1 The increasing roll of the sea, showed the gradual shallowing of the water. **1875** JOWETT *Plato* (ed. 2) V. 66 We should consider how gradual the process is by which..a legal system..becomes perfected.

b. *poet.* in *nonce-uses.* Of objects with regard to form, movement, etc.: Tapering; sloping gradually; moving or changing gradually.

1739 G. OGLE *Gualtherus & Griselda* 5 The rounded Turret, and the gradual Spire. **1742** COLLINS *Odes* ix. 40 Thy dewy fingers draw The gradual dusky veil. **1762** FALCONER *Shipwr.* I. 744 Along the arch the gradual index slides. **1850** MRS. BROWNING *Poems* I. 75 Back to the gradual banks and vernal bowers. **1890** W. WATSON *Wordsworth's Grave*, etc. 71 How welcome—after drum and trumpet's din—The continuity, the long slow slope And vast curves of the gradual violin!

c. quasi-*adv.* (*poet.*)

1736 THOMSON *Liberty* IV. 227 Arts gradual gather Streams. **1793** GILB. WHITE *Invit. Selborne* 80 There spreads the distant view, That gradual fades till sunk in misty blue. **1801** SOUTHEY *Thalaba* V. xlii, Gradual as by prayer The sin was purged away. **1808** J. BARLOW *Columb.* III. 2 Now twenty years these children of the skies Beheld their gradual growing empire rise. **1813** SCOTT *Rokeby* II. ii, What prospects, from his watch-tower high, Gleam gradual on the warder's eye! **1850** LYNCH *Theo. Trin.* V. 82 Now, gradual, earth withdraws from view.

5. *gradual psalms*: fifteen psalms (cxx-cxxxiv) each of which is entitled in the A.V. 'Song of Degrees', in R.V. 'Song of Ascents'; in the Vulgate *Canticum graduum*, in the LXX ᾠδὴ ἀναβαθμῶν = Heb. *shīr hamma‧alōth*, the sense of which is disputed. (Cf. F. *psaumes graduels*.)

1656-81 in BLOUNT *Glossogr.* **1864** PUSEY *Lect. Daniel* v. 319 Some of the gradual psalms suit well to the habitual low estate of the returned exiles. **1893** C. L. MARSON *Psalms at Work* (1894) 178/1 The gradual psalms..were for the ascent to the Temple.

Hence '**gradualness**.

1842 PUSEY *Crisis Eng. Ch.* 16 We..have been exempt from the degree of trial to which a younger generation is exposed, through the very gradualness with which our conceptions of the Unity of the Church came upon us. **1883** H. DRUMMOND *Nat. Law in Spir. W.* ii. (1884) 92 The gradualness of growth is a characteristic which strikes the simplest observer.

gradually, *adv.*

SECOND EDITION 1989

('grædjuːəlɪ, 'grædʒ(j)uːəlɪ) [f. GRADUAL *a.* + -LY[2].]

†1. In respect of degree. (Cf. GRADUAL *a.* 1.)

1649 *Bounds Publ. Obed.* (1650) 61 They..differ but gradually, just as the morning and the noon light do. **1660** F. BROOKE tr. *Le Blanc's Trav.* aiv, Saving Faith..is not only Gradually, but Specifically distinct from all common Faith. **1665** BOYLE *Occas. Refl.* (1848) 73 This use of Occasional Meditations, though it do but gradually differ from some of those that have been already mentioned. **1701** GREW *Cosmol. Sacra* II. viii. 83 Wherein Human Reason doth not only Gradually, but Specifically differ, from the Phantastick Reason of Brutes.

†2. In a graduated scale; by gradations; by degrees of relationship or rank. *Obs.* (Cf. GRADUAL *a.* 3.)

1673 *Rep. Committee, Ho. of Lords* in *Peerage* (1710) I. 263 The Petitioner, being the Heir gradually and lineally descended from the said Lord Clifton. **1678** CUDWORTH *Intell. Syst.* I. iv. 206 Several Distinct Substances, gradually subordinate to one another. **1704** *Phil. Trans.* XXV. 1626 Some of 'em gradually bigger than others. **1715** *Lond. Gaz.* No. 5371/3 If a Lieutenant inform against a Captain..he shall have his Company, so proceeding gradually to a Colonel. **1755** YOUNG *Centaur* ii. Wks. 1757 IV. 156 There are three kinds of happiness on earth, gradually less, and less.

3. By a gradual process; little by little; by degrees.

1646 SIR T. BROWNE *Pseud. Ep.* VI. x. 323 The effects of whose activity are not precipitously abrupted, but gradually proceed to their cessations. **1715** DE FOE *Fam. Instruct.* I. i. (1841) 21 You must understand it gradually, my dear, a little at a time. **1776** ADAM SMITH *W.N.* I. xi. (1869) I. 220 These metals are not likely to become gradually cheaper. **1807** T. THOMSON *Chem.* (ed. 3) II. 262 Acetous acid gradually becomes acetic acid when distilled repeatedly off dry muriate of lime. **1860** TYNDALL

Glac. I. vii. 47 The ice..being gradually melted. **1880** L. STEPHEN *Pope* vi. 157 We are softened into pity as the strong mind is seen gradually sinking into decay.

EXHIBIT O

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Hideo WATANABE

Docket No: Q64962

Appln. No.: 09/880,844

Group Art Unit: 3711

Confirmation No.: 6597

Examiner: Alvin A. HUNTER

Filed: June 15, 2001

For: GOLF BALL

AMENDMENT UNDER 37 C.F.R. § 1.111

Commissioner for Patents
Washington, D.C. 20231

Sir:

In response to the Office Action dated October 29, 2002, please amend the above-identified application as follows:

IN THE CLAIMS:

Please cancel claims 6, 11 and 16 without prejudice or disclaimer.

Please enter the following amended claims:

1. (Amended) A golf ball comprising a rubbery elastic core having a center and a radially outer surface, a cover having a plurality of dimples on the surface thereof, and at least one intermediate layer situated between the core and the cover; wherein

15. (Amended) The golf ball of claim 12, wherein the intermediate layer has a Shore D hardness of 50 to 67.

Please add the following new claims:

21. (New) A golf ball comprising a rubbery elastic core having a center and a radially outer surface, a cover having a plurality of dimples on the surface thereof, and at least one intermediate layer situated between the core and the cover, wherein

said intermediate layer is composed of a resin material which is harder than the cover having a Shore D hardness of 45 to 58 and has a greater hardness than the surface of the elastic core when compared using the same hardness scale, and

said elastic core has a hardness at the center and a hardness at the surface thereof which is greater than the hardness at the center thereof, and a difference in JIS-C hardness of at least 18 between the center and the surface.

REMARKS

Claims 1-5, 7-11, 12-15, 17-21 are all the claims now pending in the application. Claims 6, 11 and 16 have been canceled and claim 21 has been added as a new claim.

I. Claim Objections

Claims 14 and 15 stand objected to for each containing a typographical informality. Applicant has amended the claims and corrected the informalities as suggested by the Examiner. The scope of the claims has not been narrowed. Therefore, Applicant respectfully requests that the objection to claims 14 and 15 be reconsidered and withdrawn.

II. Claim Rejections under 35 U.S.C. § 103

Claims 1, 2, 4-5, 7-8, 10-18 and 20 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Moriyama et al. (U.S. Patent No. 6,336,872) in view of Nakamura et al. (U.S. Patent No. 5,803,833) and Farrally et al. (Science and Golf III). To establish a *prima facie* case of obviousness the Examiner must show that the prior art references, when combined, teach or suggest all of the claim limitations. See MPEP § 2143. Applicant respectfully submits that the references cited above by the Examiner fail to teach or suggest all of the claim limitations as set forth in the present application.

A. **References do not teach an intermediate layer which is harder than the cover.**

Moriyama fails to teach an intermediate layer which is harder than the cover. In fact, Moriyama teaches the opposite relationship, namely, an intermediate layer that is softer than the

cover. Specifically, Moriyama discloses that "[i]n the golf ball of the present invention, it is required that a JIS-C hardness of the outer layer 3 is higher than the hardness of the intermediate layer 2 by 15 to 40, preferably 19 to 37". Moriyama col. 5:20-23. Nakamura fails to cure this deficiency because the golf ball disclosed in the Nakamura reference is a two-piece solid golf ball, and thus, the golf ball of Nakamura does not have an intermediate layer. Consequently, Nakamura cannot teach an intermediate layer that is harder than the cover. Finally, Farrally discloses that a hard inner layer (or mantle) material should show increased resilience with hardness, such as ionomers or crosslinked polybutadiene, and a soft mantle material should be one that shows increased resilience as the material becomes softer, such as metallocenes like "Exact" or "Engage", polyester elastomers such as "Hytrel", or polyester amides such as "Pebax." However, Farrally merely discloses the relationship between resilience and hardness in the general materials of golf balls, which does not teach or suggest that the intermediate layer is harder than the cover as claimed. The Examiner uses Farrally to teach that it is simply a matter of design choice to have the intermediate layer be harder than the outer cover layer depending on the Applicant's desired results. While Farrally teaches the relationship between resilience and hardness in the general materials of golf balls, it fails to teach when or why one would have found it obvious, in view of the teachings of Moriyama, to modify the hardness of the intermediate layer to be harder than the outer cover layer.

Accordingly, none of the cited references teaches or suggests the claimed relationship of an intermediate layer being harder than the cover.

B. References do not teach an intermediate layer having a greater hardness than the surface of the core.

Moriyama fails to teach or suggest an intermediate layer having a greater hardness than the surface of the elastic core. Once again, Moriyama teaches the complete opposite relationship. Specifically, Moriyama teaches that "the JIS-C hardness of the intermediate layer is lower than the surface hardness of the center by 0 to 10." Moriyama col. 2:8-10 (emphasis added). Again, Nakamura fails to cure this deficiency because the golf ball disclosed in the Nakamura reference is a two-piece solid golf ball, and thus, the golf ball of Nakamura does not have an intermediate layer. Consequently, Nakamura cannot teach an intermediate layer that is harder than the surface of the core. Finally, as discussed above, Farrally does not teach or suggest any hardness relationship between the intermediate layer and the surface of the core. Accordingly, none of the cited references teaches or suggests the claimed relationship of an intermediate layer being harder than the surface of the core.

C. References do not teach an elastic core having a difference in JIS-C hardness of at least 18 between the core center and the core surface.

Moriyama fails to teach or suggest a difference in JIS-C hardness of at least 18 between the core center and the core surface. Moriyama teaches that the difference in JIS-C hardness between the core center and core surface is less than 10. Moriyama col. 2:6-8; col. 3:23-26. Moriyama explains that the reason why the difference therebetween is less than 10 is that when the hardness difference is larger than 10, "the rebound characteristics are not sufficiently obtained and the shot feel is heavy and poor." Id. col. 3:27-30. On the other hand, the present

specification describes at least one reason why the elastic core has a difference in JIS-C hardness of at least 18 between the center and the surface:

> The difference in hardness within the core gives the ball a low spin when hit with a driver (number 1 wood), enabling it to travel well and thus attain a good total distance. Too small a difference in JIS-C hardness between the relatively soft center and the relatively hard surface of the core allows the ball to take on too much spin when hit with a driver, so that it does not travel well and has a short run after it lands on the ground. This makes it impossible to achieve the desired distance.

Specification page 5, lines 22-33.

Thus, since neither Nakamura nor Farrally cure the deficient teachings of Moriyama, Applicant submits that the references, either alone or in combination, do not disclose and suggest the difference of the claimed hardness and the effects thereof.

D. References fail to teach a core which gradually increases radially outward from the center to the surface thereof.

Applicant submits that the combination of these references fails to teach a core which "gradually increases radially outward from the center to the surface thereof." The Examiner acknowledges on page 3 of the office action that Moriyama fails to teach this feature, but then contends that Nakamura teaches this gradually increasing hardness of the core. However, Nakamura teaches that from 4 mm from the core's surface to 2 mm from the core 's surface, the hardness actually decreases. Nakamura col. 2:54-64; Abstract. Therefore, the core of Nakamura fails to gradually increase from the core center to the core surface. Accordingly, the cited references fail to teach or suggest this limitation.

In view of the above remarks, Applicant submits that the references fail to teach or suggest all of claimed limitations. Therefore, Applicant respectfully requests that the rejection of claims 1, 2, 4-5, 7-8, 10-18 and 20 under 35 U.S.C. § 103(a) be reconsidered and withdrawn.

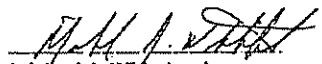
III. Double Patenting

Claims 1-20 are provisionally rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-9 of copending Application No. 09/881,119 in view of Farrally et al. (Science and Golf III). Applicant submits herewith a terminal disclaimer which disclaims the terminal part of any patent issuing from the present application. However, the submission of the terminal disclaimer is not intended as an admission that the claims of the patent application applied by the Examiner are substantively sufficient to support the Examiner's rejection. Therefore, Applicant respectfully requests that the double patenting rejection be reconsidered and withdrawn.

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,



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Facsimile: (202) 293-7860

Date: January 29, 2003

APPENDIX

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Claims 6, 11 and 16 are canceled.

The claims are amended as follows:

1. (Amended) A golf ball comprising a rubbery elastic core having a center and a radially outer surface, a cover having a plurality of dimples on the surface thereof, and at least one intermediate layer situated between the core and the cover; wherein

said intermediate layer is composed of a resin material which is harder than the cover and has a greater hardness than the surface of the elastic core when compared using the same hardness scale, and

said elastic core has a hardness which gradually increases radially outward from the center to the surface thereof, and ~~is harder at the surface of the elastic core than said intermediate layer and a difference in JIS-C hardness between the center of the elastic core and the surface thereof is 21 to 30 and undergoes a deformation of 3.5 to 6.0 mm when the load applied thereto is increased from an initial load of 98 n (10 kgf) to a final load of 1,275 N (130 kgf)~~ a difference in JIS-C hardness of at least 18 between the center and the surface.

12. (Amended) A golf ball comprising a rubbery elastic core having a center and a radially outer surface, a cover having a plurality of dimples on the surface thereof, and at least one intermediate layer situated between the core and the cover, wherein

said intermediate layer is composed of a resin material which is harder than the cover, and has a greater hardness than the surface of the elastic core when compared using the same JIS-C hardness scale, and

said elastic core has a hardness at the center and a hardness at the surface thereof which is greater than the hardness at the center thereof, and a difference in JIS-C hardness of at least 18 between the center and the surface.

14. (Amended) The golf ball of claim 12, wherein the difference in ~~JIS-C~~JIS-C hardness between the center of the elastic core and the surface thereof is 18 to 30 units.

15. (Amended) The golf ball of claim 12, wherein the intermediate ~~layer~~intermediate layer has a Shore D hardness of 50 to 67.

New claim 21 is added.

EXHIBIT P

Interview Summary	Application No. 09/860,844	Applicant(s) WATANABE, HIDEO	
	Examiner Alvin A. Hunter	Art Unit 3711	

All participants (applicant, applicant's representative, PTO personnel):

(1) *Alvin A. Hunter*. (3) *Michael Whitehead*.

(2) *Paul Sewell*. (4)_____.

Date of Interview: *25 February 2003*.

Type: a)☐ Telephonic b)☐ Video Conference
c)☒ Personal [copy given to: 1)☐ applicant 2)☒ applicant's representative]

Exhibit shown or demonstration conducted: d)☐ Yes e)☒ No.
If Yes, brief description: _____.

Claim(s) discussed: *1*.

Identification of prior art discussed: *Moriyama et al. (USPN 6336872), Nakamura et al. (USPN 5803833), and Farrally et al. (Science and Golf III)*.

Agreement with respect to the claims f)☐ was reached. g)☐ was not reached. h)☒ N/A.

Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: *See Continuation Sheet*.

(A fuller description, if necessary, and a copy of the amendments which the examiner agreed would render the claims allowable, if available, must be attached. Also, where no copy of the amendments that would render the claims allowable is available, a summary thereof must be attached.)

i)☒ It is not necessary for applicant to provide a separate record of the substance of the interview(if box is checked).

Unless the paragraph above has been checked, THE FORMAL WRITTEN REPLY TO THE LAST OFFICE ACTION MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW. (See MPEP Section 713.04). If a reply to the last Office action has already been filed, APPLICANT IS GIVEN ONE MONTH FROM THIS INTERVIEW DATE TO FILE A STATEMENT OF THE SUBSTANCE OF THE INTERVIEW. See Summary of Record of Interview requirements on reverse side or on attached sheet.

Examiner Note: You must sign this form unless it is an Attachment to a signed Office action.

Examiner's signature, if required

Continuation Sheet (PTO-413) Application No. 09/880,844

Continuation of Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: Applicant's representative argues that there is no teaching of the core gradually increasing from the center to the surface because Moriyama is silent on the matter and that Nakemura shows fluxing hardness within the core. The examiner agrees to reconsider the claims. Applicant's representative also argues that there is no teaching of the intermediate layer being higher than the cover because Moriyama et al. teaches an intermediate layer softer than the cover and that Farrally et al. would change the operation of the invention. Distinctions were discussed between the applicant's representative and examiner of the core's hardness gradually increasing from the center and the cover being softer than the intermediate layer.

EXHIBIT Q

US006336872B1

(12) **United States Patent**
Moriyama et al.

(10) Patent No.: US 6,336,872 B1
(45) Date of Patent: Jan. 8, 2002

(54) MULTI-PIECE SOLID GOLF BALL

(75) Inventors: Keiji Moriyama; Takashi Sasaki, both of Akashi; Takeshi Asakura, Fukuchiyama; Satoshi Iwami, Akashi, all of (JP)

(73) Assignee: Sumitomo Rubber Industries, Ltd., Kobe (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(30) Foreign Application Priority Data

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(51) Int. Cl.[7] A63B 37/06

(52) U.S. Cl. 473/374

(58) Field of Search 473/373, 374, 473/367, 368, 370–371

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Primary Examiner—Mark S. Graham
Assistant Examiner—Raeann Gorden
(74) *Attorney, Agent, or Firm*—Birch, Stewart, Kolasch & Birch, LLP

(57) ABSTRACT

The present invention provides a multi-piece solid golf ball having excellent flight performance and good shot feel at the time of hitting. The present invention relates to a multi-piece solid golf ball comprising a center having at least one layer, an intermediate layer formed on the center, and an outer layer covering the intermediate layer, wherein the center has a JIS-C hardness of 65 to 85, a surface hardness of the center is higher than a central point hardness of the center by not more than 10, a JIS-C hardness of the intermediate layer is lower than the surface hardness of the center by 0 to 10, a JIS-C hardness of the outer layer is higher than the hardness of the intermediate layer by 15 to 40.

8 Claims, 1 Drawing Sheet

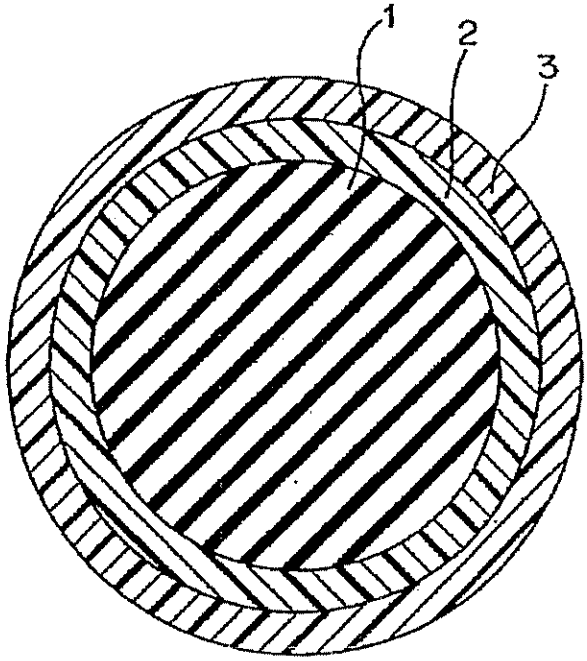
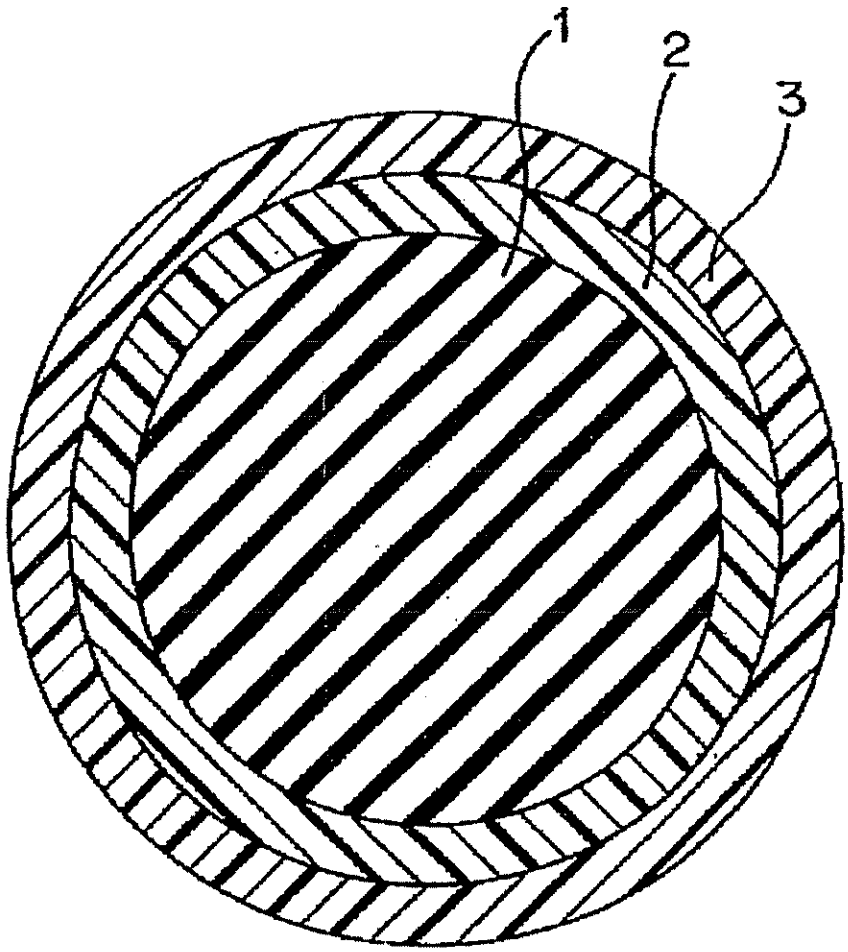


Fig. 1



MULTI-PIECE SOLID GOLF BALL

FIELD OF THE INVENTION

The present invention relates to a multi-piece solid golf ball. More particularly, it relates to a multi-piece solid golf ball having excellent flight performance and good shot feel at the time of hitting.

BACKGROUND OF THE INVENTION

Many types of golf balls are commercially selling, but they are typically classified into solid golf balls such as two-piece golf balls, three-piece golf balls and thread wound golf balls. The solid golf balls generally occupy the greater part of the golf ball market, because they inherently have longer flight distance than the thread wound golf balls and have been improved to have soft and good shot feel at the time of hitting as good as the thread wound golf ball. The three-piece golf ball, when compared with the two-piece golf ball, has better shot feel while maintaining excellent flight performance, because the three-piece golf ball can vary in hardness distribution.

The three-piece solid golf balls are obtained by inserting an intermediate layer between the core and the cover layer constituting the two-piece solid golf ball and have been described in Japanese Patent Kokai Publication Nos. 244174/1992, 10357/1997, 10358/1997, 117532/97, 313643/1997 and Japanese Patent Nos. 257587 and 2658811. In these golf balls, it has been attempted to compromise the balance of flight performance and shot feel at the time of hitting by using thermoplastic resin, such as a block copolymer of amides, polyester thermoplastic elastomer, ionomer resin, polyolefin, for the intermediate layer, to adjust the hardness of the core, intermediate layer and cover and the hardness distribution thereof to a proper range.

However, the golf ball having sufficient performances has not been obtained in view of the balance of flight performance and shot feel. Therefore, it is required to provide a golf ball having longer flight distance and better shot feel.

OBJECTS OF THE INVENTION

A main object of the present invention is to provide a multi-piece solid golf ball having excellent flight performance and good shot feel at the time of hitting.

According to the present invention, the object described above has been accomplished by placing an intermediate layer between at least one layer of center and an outer layer to make a multi-piece solid golf ball, and adjusting a hardness and hardness distribution of the center, a hardness difference between the center and the intermediate layer and the hardness difference between the intermediate layer and the outer layer to specified ranges, thereby providing a multi-piece solid golf ball having excellent flight performance and good shot feel at the time of hitting.

This object as well as other objects and advantages of the present invention will become apparent to those skilled in the art from the following description with reference to the accompanying drawings.

BRIEF EXPLANATION OF DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustrating only, and thus are not limitative of the present invention, and wherein:

FIG. 1 is a schematic cross section illustrating one embodiment of the golf ball of the present invention.

SUMMARY OF THE INVENTION

The present invention provides a multi-piece solid golf ball comprising a center having at least one layer, an intermediate layer formed on the center, and an outer layer covering the intermediate layer, wherein the center has a JIS-C hardness of 65 to 85, the surface hardness of the center is higher than the central point hardness of the center by not more than 10; and the JIS-C hardness of the intermediate layer is lower than the surface hardness of the center by 0 to 10, and the JIS-C hardness of the outer layer is higher than the hardness of the intermediate layer by 15 to 40.

DETAILED DESCRIPTION OF THE INVENTION

The multi-piece solid golf ball of the present invention will be explained with reference to the accompanying drawing in detail. FIG. 1 is a schematic cross section illustrating one embodiment of the multi-piece solid golf ball of the present invention. As shown in FIG. 1, the golf ball of the present invention comprises a center 1 and an intermediate layer 2 formed on the center 1, and an outer layer 3 covering the intermediate layer 2. The center 1 is formed from a rubber composition comprising a base rubber, a co-crosslinking agent, an organic peroxide, a filler, and optionally an antioxidant and the like.

The base rubber used in the present invention may be natural rubber and/or synthetic rubber, which have been conventionally used for solid golf balls. Preferred is high-cis polybutadiene rubber containing not less than 40%, preferably not less than 80% of a cis-1,4 bond. The high-cis polybutadiene rubber may be mixed with natural rubber, polyisoprene rubber, styrene-butadiene rubber, ethylene-propylene-diene rubber (EPDM) and the like.

The co-crosslinking agent can be a metal salt of α,β-unsaturated carboxylic acid, including mono or divalent metal salts, such as zinc or magnesium salts of α,β-unsaturated carboxylic acids having 3 to 8 carbon atoms (e.g. acrylic acid, methacrylic acid, etc.). The preferred co-crosslinking agent is zinc acrylate because it imparts high rebound characteristics to the resulting golf ball. The amount of the co-crosslinking agent in the rubber composition is from 20 to 40 parts by weight, preferably from 25 to 35 parts by weight, based on 100 parts by weight of the base rubber. When the amount of the co-crosslinking agent is smaller than 20 parts by weight, the center is too soft, and the rebound characteristics are degraded, which reduces flight distance. On the other hand, when the amount of the co-crosslinking agent is larger than 40 parts by weight, the center is too hard, and shot feel is hard and poor.

The organic peroxide, which acts as a crosslinking agent or curing agent, includes, for example, dicumyl peroxide, 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, 2,5-dimethyl-2,5-di(t-butylperoxy)hexane, di-t-butyl peroxide and the like. The preferred organic peroxide is dicumyl peroxide. The amount of the organic peroxide is from 0.5 to 2.5 parts by weight, preferably 0.5 to 2.0 parts by weight, based on 100 parts by weight of the base rubber. When the amount of the organic peroxide is smaller than 0.5 parts by weight, the center is too soft, and the rebound characteristics are degraded, which reduces flight distance. On the other hand, when the amount of the organic peroxide is larger than 2.5 parts by weight, the center or the intermediate layer is too hard, and the shot feel is poor.

The filler used for the center 1 of the present invention, which can be typically used for the center of golf ball, includes for example, inorganic filler (such as zinc oxide, barium sulfate, calcium carbonate and the like), high specific gravity metal powder filler (such as tungsten powder, molybdenum powder and the like), and the mixture thereof.

The amount of the filler is from 5 to 60 parts by weight, preferably from 10 to 55 parts by weight, based on 100 parts by weight of the base rubber. When the amount of the filler is smaller than 5 parts by weight, the center is too light, and thus the resulting golf ball is too light. On the other hand, when the amount of the filler is larger than 60 parts by weight, the center is too heavy, and the resulting golf ball is too heavy.

The rubber composition for the center 1 of the golf ball of the present invention can contain other components, which have been conventionally used for preparing the core of solid golf balls, such as a peptizing agent or an antioxidant. If used, an amount of the antioxidant is preferably 0.2 to 1.5 parts by weight, based on 100 parts by weight of the base rubber.

The center 1 is obtained by mixing the above rubber composition, and then vulcanizing and press-molding the mixture in a mold. It is required that the center 1 of the golf ball of the present invention have a JIS-C hardness of 65 to 85, preferably 65 to 80, more preferably 65 to 75. When the hardness is lower than 65, the deformation amount at the time of hitting is too large, which reduces the flight distance. On the other hand, when the hardness is higher than 85, the center is too hard, the shot feel is hard and poor. It is required that the center 1 of the golf ball of the present invention has a difference between the surface hardness and central point hardness of not more than 10, preferably not more than 7. When the hardness difference is larger than 10, the central point hardness of the center 1 is too low, and the rebound characteristics are not sufficiently obtained and the shot feel is heavy and poor. The center 1 used for the golf ball of the present invention may have a multi-layered structure, which has two or more layers. If the center has a multi-layer structure, it is required that the center 1 has a difference between the surface hardness of the outmost layer and the central point hardness of not more than 10. The term "central point hardness of the center" as used herein refers to a hardness, which is obtained by cutting the center into two equal parts and then measuring the hardness at the center point.

It is desired that the center 1 of the golf ball of the present invention have a diameter of 34.5 to 37.5 mm, preferably 35 to 37 mm. When the diameter of the center 1 is smaller than 34.5 mm, the technical effect of heightening the rebound characteristics accomplished by the presence of the center is not sufficiently obtained. On the other hand, when the diameter is larger than 37.5 mm, the thickness of the intermediate layer is too thin, and the technical effects accomplished by the presence of the intermediate layer are not sufficiently obtained. The intermediate layer 2 is then formed on the center 1.

The material suitably used for the intermediate layer 2 of the present invention is not limited, but includes ionomer resin, polystyrene thermoplastic elastomer, polyurethane thermoplastic elastomer, polyamide thermoplastic elastomer, polyester thermoplastic elastomer, an SBS (styrene-butadiene-styrene) block copolymer having polybutadiene portion with epoxy groups or SIS (styrene-isoprene-styrene) block copolymer having polyisoprene portion with epoxy groups, thermoplastic elastomer having terminal OH groups, or combinations thereof. The ionomer resin may be a copolymer of α-olefin and α,β-unsaturated carboxylic acid having 3 to 8 carbon atoms, of which a portion of carboxylic acid groups is neutralized with metal ion. Examples of the α-olefins in the ionomer preferably include ethylene, propylene and the like. Examples of the α,β-unsaturated carboxylic acid in the ionomer preferably include acrylic acid, methacrylic acid and the like. The metal ion which neutralizes a portion of carboxylic acid groups of the copolymer includes an alkali metal ion, such as a sodium ion, a potassium ion, a lithium ion and the like; a divalent metal ion, such as a zinc ion, a calcium ion, a magnesium ion and the like; a trivalent metal ion, such as an aluminum, a neodymium ion and the like; and mixture thereof. Preferred are sodium ions, zinc ions, lithium ions and the like, in view of rebound characteristics, durability and the like. The ionomer resin is not limited, but examples thereof will be shown by a trade name thereof. Examples of the ionomer resins, which are commercially available from Mitsui Du Pont Polychemical Co., Ltd. include Hi-milan 1555, Hi-milan 1557, Hi-milan 1605, Hi-milan 1652, Hi-milan 1705, Hi-milan 1706, Hi-milan 1707, Hi-milan 1855, Hi-milan 1856 and the like. Examples of the ionomer resins, which are commercially available from Du Pont Co., include Surlyn 9945, Surlyn 8945, Surlyn AD8511, Surlyn AD8512 and the like. Examples of the ionomer resins, which are commercially available from Exxon Chemical Co., include Iotek 7010, Iotek 8000 and the like. These ionomer resins may be used alone or in combination.

The composition of the intermediate layer used in the present invention may optionally contain fillers and the like, in addition to the resin component as main component. Examples of fillers include inorganic filler (such as zinc oxide, barium sulfate, calcium carbonate and the like), high specific gravity metal powder filler (such as tungsten powder, molybdenum powder and the like), and the mixture thereof.

A method of forming the intermediate layer 2 is not specifically limited, but may be a well-known method, which has been conventionally used for forming golf ball cover. For example, there can be used a method comprising molding the intermediate layer composition into a semi-spherical half-shell, covering the center with the two half-shells, followed by pressure molding, or a method comprising injection molding the intermediate layer composition directly on the center to cover it.

In the golf ball of the present invention, it is required that the JIS-C hardness of the intermediate layer 2 is lower than the surface hardness of the center 1 by 0 to 10, preferably 5 to 10. When the hardness difference is larger than 10, the golf ball does not deform at all, but it deforms only at the portion contacted with the club face of the golf club, and the contact area is large and the spin amount is large. Therefore the golf ball creates a blow-up trajectory, which reduces the flight distance. On the other hand, when the hardness difference is smaller than 0, that is, when the hardness of the intermediate layer is higher than the surface hardness of the center, the hardness of the outer portion of the golf ball is high, and the deformation amount of the golf ball is small when hit at low head speed and the launch angle is small, which reduces the flight distance.

It is desired that the intermediate layer 2 have a JIS-C hardness of 60 to 85, preferably 62 to 80. When the hardness is higher than 85, the shot feel is poor. On the other hand, when the hardness is lower than 60, the rebound characteristics are degraded. The term "hardness of the intermediate layer" as used herein refers to the surface hardness in JIS-C hardness of the molded article, which is obtained by covering the center 1 with the intermediate layer 2.

It is desired that the intermediate layer 2 of the golf ball of the present invention have a thickness of 1.0 to 1.8 mm, preferably 1.3 to 1.8 mm. When the thickness is smaller than 1.0 mm, the deformation amount of the golf ball at the time of hitting is small and the launch angle is small, which reduces the flight distance. On the other hand, when the thickness is larger than 1.8 mm, the golf ball deforms only at a portion contacted with a club face of a golf club, and the contact area is large and the spin amount is large. Therefore the golf ball creates blow-up trajectory, which reduces the flight distance. The outer layer 3 is then covered on the intermediate layer 2.

The material that can be used for the outer layer 3 of the present invention includes thermoplastic resin, particularly ionomer resin, which is the same as used for the intermediate layer 2, or mixtures thereof. As the materials used in the outer layer 3 of the present invention, the above ionomer resin may be used alone, but the ionomer resin may be suitably used in combination with thermoplastic elastomer or resin, which is the same as used for the intermediate layer 2

The outer layer used in the present invention may optionally contain fillers (such as barium sulfate, calcium carbonate, etc.), pigments (such as titanium dioxide, etc.), and other additives such as a dispersant, an antioxidant, a UV absorber, a photostabilizer and fluorescent agent or fluorescent brightener, etc., in addition to the resin component as main component, as long as the addition of the additives does not deteriorate the desired performance of the outer layer of the golf ball. The amount of the pigment is preferably 0.1 to 0.5 parts by weight, based on 100 parts by weight of the resin component for the outer layer.

In the golf ball of the present invention, it is required that a JIS-C hardness of the outer layer 3 is higher than the hardness of the intermediate layer 2 by 15 to 40, preferably 19 to 37. When the hardness difference is larger than 40, the shot feel is heavy and is felt so that the golf ball stick to the club face of the golf club, and is poor. On the other hand, the hardness difference is smaller than 15, the shot feel is hard and poor. When the JIS-C hardness of the outer layer 3 is too low, the rebound characteristics are degraded. Therefore it is desired that the JIS-C hardness of the outer layer 3 is not less than 90, preferably not less than 95. When the JIS-C hardness of the outer layer 3 is too high, the shot feel is poor. Therefore it is desired that the JIS-C hardness of the outer layer 3 is 90 to 100, preferably 95 to 100. The term "hardness of the outer layer" as used herein refers to the surface hardness in JIS-C hardness of the golf ball, which is obtained by covering the intermediate layer 2 formed on the center 1 with the outer layer 3.

The outer layer 3 has a thickness of 1.5 to 2.3 mm, preferably 1.5 to 1.9 mm. When the thickness is smaller than 1.5 mm, the rebound characteristics are not sufficiently obtained, and the velocity of the golf ball is low. On the other hand, when the thickness is larger than 2.3 mm, the golf ball is too hard, and the launch angle is small.

A method of covering the intermediate layer with the outer layer 3 is not specifically limited, but may be the same method as used in the intermediate layer. At the time of molding the outer layer, many depressions called "dimples" may be optionally formed on the surface of the golf ball. Furthermore, paint finishing or marking with a stamp may be optionally provided after the outer layer is molded for commercial purpose. The multi-piece solid golf ball of the present invention is formed, so that it has a diameter of not less than 42.67 mm and a weight of not more than 45.93 g, according to the PGA rule.

EXAMPLES

The following Examples and Comparative Examples further illustrate the present invention in detail but are not to be construed to limit the scope of the present invention.

(Examples 1 to 8 and Comparative Examples 1 to 7)

Production of Center

The rubber compositions for the center shown in Table 1 (Examples) and Table 2 (Comparative Examples) were mixed with a mixing roll, and then vulcanized by press-molding at the vulcanization condition shown in the same Tables to obtain spherical centers. The central point hardness A, surface hardness B and diameter of the resulting centers were measured, and the hardness difference (B-A) was calculated. The results are shown in Tables 5 and 6 (Examples) and Tables 7 and 8 (Comparative Examples). The test methods are described later.

TABLE 1

	Example No.							
	1	2	3	4	5	6	7	8
Center composition								
BR18*1	100	100	100	100	100	100	100	100
Zinc acrylate	26	26	26	26	33	26	26	26
Zinc oxide	22.2	22.2	24.1	22.2	19.9	24.7	28.0	31.9
Barium sulfate	10	10	10	10	10	10	10	10
Dicumyl peroxide	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Diphenyl disulfide	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Vulcanization condition								
The first stage								
Temp. (° C.)	145	155	155	145	160	150	150	150
Time (min)	22	26	26	22	26	22	22	22
The second stage								
Temp. (° C.)	165	—	—	165	—	165	165	165
Time (min)	8	—	—	8	—	8	8	8

TABLE 2

	Comparative Example No.						
	1	2	3	4	5	6	7
Center composition							
BR18*1	100	100	100	100	100	100	100
Zinc acrylate	25	31	26	33	22.2	26	33
Zinc oxide	22.5	19.0	10.6	19.9	15.6	22.2	19.9
Barium sulfate	10	10	10	10	10	10	10
Dicumyl peroxide	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Diphenyl disulfide	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Vulcanization condition							
The first stage							
Temp. (° C.)	160	165	150	145	145	145	160
Time (min)	26	26	22	22	22	22	26
The second stage							
Temp. (° C.)	—	—	165	165	165	165	—
Time (min)	—	—	8	8	8	8	—

*1 High-cis Polybutadiene rubber (trade name "BR18") available from JSR Co., Ltd.

Preparation of Intermediate Layer and Outer Layer Compositions

The formulation materials shown in Table 3 (Examples) and Table 4 (Comparative Examples) were mixed using a kneading type twin-screw extruder to obtain pelletized intermediate layer and outer layer compositions.

The extrusion condition was,

a screw diameter of 45 mm,

a screw speed of 200 rpm, and

a screw L/D of 35.

The formulation materials were heated at 200 to 260° C. at the die position of the extruder.

TABLE 3

	Example No.							
	1	2	3	4	5	6	7	8
Intermediate layer composition								
Surlyn 9945*2	10	10	10	20	30	10	10	10
Surlyn 8945*3	10	10	10	20	30	10	10	10
Septon HG-252*4	80	80	80	60	40	80	80	80
Elastoran ET880*5	—	—	—	—	—	—	—	—
Hi-milan 1855*6	—	—	—	—	—	—	—	—
Pebax 2533S*7	—	—	—	—	—	—	—	—
Epofriend A1010*8	—	—	—	—	—	—	—	—
Outer layer composition								
Hi-milan 1605*9	60	60	60	60	60	60	60	60
Hi-milan 1706*10	40	40	40	40	40	40	40	40
Surlyn 9945*2	—	—	—	—	—	—	—	—
Surlyn 8945*3	—	—	—	—	—	—	—	—
Hi-milan 1855*6	—	—	—	—	—	—	—	—
Pebax 2533S*7	—	—	—	—	—	—	—	—
Epofriend A1010*8	—	—	—	—	—	—	—	—
Titanium dioxide	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Barium sulfate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Antioxidant*11	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

TABLE 4

	Comparative Example No.						
	1	2	3	4	5	6	7
Outer layer composition							
Surlyn 9945*2	10	10	—	30	37	30	40
Surlyn 8945*3	10	10	—	30	46	30	40
Septon HG-252*4	80	80	—	40	—	40	20
Elastoran ET880*5	—	—	100	—	—	—	—
Hi-milan 1855*6	—	—	—	—	10	—	—
Pebax 2533S*7	—	—	—	—	5	—	—
Epofriend A1010*8	—	—	—	—	2	—	—
Outer layer composition							
Hi-milan 1605*9	60	60	60	60	60	60	—
Hi-milan 1706*10	40	40	40	40	40	40	—
Surlyn 9945*2	—	—	—	—	—	—	37
Surlyn 8945*3	—	—	—	—	—	—	46
Hi-milan 1855*6	—	—	—	—	—	—	10
Pebax 2533S*7	—	—	—	—	—	—	5
Epofriend A1010*8	—	—	—	—	—	—	2
Titanium dioxide	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Barium sulfate	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Antioxidant*11	0.02	0.02	0.02	0.02	0.02	0.02	0.02

*2 Surlyn 9945 (trade name), ethylene-methacrylic acid copolymer ionomer resin obtained by neutralizing with zinc ion, manufactured by DuPont Co.
*3 Surlyn 8945 (trade name), ethylene-methacrylic acid copolymer ionomer resin obtained by neutralizing with sodium ion, manufactured by DuPont Co.
*4 Septon HG-252 (trade name), hydrogenated styrene-isoprene-styrene (SIS) block copolymer having a terminal OH group, manufactured by Kuraray Co. Ltd.

TABLE 4-continued

	Comparative Example No.						
	1	2	3	4	5	6	7

*5 Polyurethane elastomer (trade name "Elastoran ET880") available from Takeda Verdische Urethane Industries, Ltd.
*6 Hi-milan 1855 (trade name), ethylene-methacrylic acid-isobutyl acrylate terpolymer ionomer resin obtained by neutralizing with zinc ion, manufactured by Mitsui DuPont Polychemical Co., Ltd.
*7 Pebax 2533S (trade name), polyamide thermoplastic elastomer, manufactured by ELF Atochem Co.
*8 Epofriend AT1010 (trade name), styrene-butadiene-styrene (SBS) block copolymer with epoxy groups, manufactured by Daicel Chemical Industries, Ltd., JIS-A hardness = 67, styrene/butadiene (weight ratio) = 40/60, content of epoxy = about 1.5 to 1.7% by weight
*9 Hi-milan 1605 (trade name), ethylene-methacrylic acid copolymer ionomer resin obtained by neutralizing with sodium ion, manufactured by Mitsui DuPont Polychemical Co., Ltd.
*10 Hi-milan 1706 (trade name), ethylene-methacrylic acid copolymer ionomer resin obtained by neutralizing with zinc ion, manufactured by Mitsui DuPont Polychemical Co., Ltd.
*11 Sanol LS770 (trade name), antioxidant manufactured by Sankyo Co., Ltd.

Formation of Intermediate Layer

The compositions for the intermediate layer were injection molded on the center to form the intermediate layer. The JIS-C hardness C and thickness of the intermediate layer were measured, and the hardness difference (B-C) was calculated. The results are shown in Tables 5 and 6 (Examples) and Tables 7 and 8 (Comparative Examples).

Production of Golf Ball

The compositions for the outer layer were covered on the intermediate layer by injection molding to form the outer layer. The JIS-C hardness D and thickness of the resulting outer layer were measured, and the hardness difference (D-C) was calculated. The results are shown in Tables 5 and 6 (Examples) and Tables 7 and 8 (Comparative Examples). Then, deflashing, surface pretreatment for painting, paint and the like, which are generally done on the surface of a golf ball, were conducted on the surface to produce a golf ball having a diameter of 42.7 mm. With respect to the resulting golf balls, the flight performance and shot feel were evaluated. The results are shown in Tables 5 and 6 (Examples) and Tables 7 and 8 (Comparative Examples). As the flight performance, launch angle, spin amount and flight distance (carry). The test methods are as follows.

(Test Method)

(1) Flight Performance

A No. 1 wood club (W#1, a driver) was mounted to a swing robot manufactured by True Temper Co. and the golf ball was hit at a head speed of 40 m/second, the launch angle, flight distance and spin amount were measured. As the flight distance, carry that is a distance to the dropping point of the hit golf ball was measured. The spin amount was measured by continuously taking a photograph of a mark provided on the hit golf ball using a high-speed camera.

(2) Shot Feel

The shot feel of the golf ball is evaluated by 10 golfers according to a practical hitting test using a No. 1 wood club. The evaluation criteria are as follows.

Evaluation criteria:

○: Not less than 7 out of 10 golfers felt that the golf ball has soft and good shot feel.

Δ: From 4 to 6 out of 10 golfers felt that the golf ball has soft and good shot feel.

XW: Not less than 7 out of 10 golfers felt that the golf ball has slightly heavy and poor shot feel.

XWW: Not less than 7 out of 10 golfers felt that the golf ball has heavy and poor shot feel.

XH: Not less than 7 out of 10 golfers felt that the golf ball has hard and poor shot feel.

TABLE 5

	Example No. 1	2	3	4
	(Center)			
JIS-C hardness				
Central point hardness (A)	71	65	65	71
Surface hardness (B)	72	72	72	72
Hardness difference (B – A)	1	7	7	1
Diameter (mm)	36.4	36.4	36.0	36.4
	(Intermediate layer)			
Hardness (C) (JIS-C)	62	62	62	71
Hardness difference (B – C)	10	10	10	1
Thickness (mm)	1.6	1.6	1.8	1.6
	(Outer layer)			
Hardness (D) (JIS-C)	99	99	99	99
Hardness difference (D – C)	37	37	37	28
Thickness (mm)	1.55	1.55	1.55	1.55
	(Golf ball)			
Flight performance				
Launch angle (degree)	12.8	12.9	12.7	12.6
Spin amount (rpm)	2785	2690	2790	2810
Carry (yard)	197.4	198.6	197.9	196.8
Shot feel	O	O	O	O

TABLE 6

	Example No. 5	6	7	8
	(Center)			
JIS-C hardness				
Central point hardness (A)	75	68	68	68
Surface hardness (B)	85	72	72	72
Hardness difference (B – A)	10	4	4	4
Diameter (mm)	36.4	35.8	35.3	34.5
	(Intermediate layer)			
Hardness (C) (JIS-C)	80	62	62	62
Hardness difference (B – C)	5	10	10	10
Thickness (mm)	1.6	1.6	1.6	1.6
	(Outer layer)			
Hardness (D) (JIS-C)	99	99	99	99
Hardness difference (D – C)	19	37	37	37
Thickness (mm)	1.55	1.85	2.10	2.50
	(Golf ball)			
Flight performance				
Launch angle (degree)	12.85	12.75	12.7	12.6
Spin amount (rpm)	2710	2750	2740	2820
Carry (yard)	198.3	197.5	197.3	196.9
Shot feel	O	O	O	O

TABLE 7

	Comparative Example No. 1	2	3	4
	(Center)			
JIS-C hardness				
Central point hardness (A)	60	65	68	85
Surface hardness (B)	70	80	72	88
Hardness difference (B – A)	10	15	4	3
Diameter (mm)	36.4	36.4	36.4	36.4
	(Intermediate layer)			
Hardness (C) (JIS-C)	62	62	55	80
Hardness difference (B – C)	8	18	17	8
Thickness (mm)	1.6	1.6	1.6	1.6
	(Outer layer)			
Hardness (D) (JIS-C)	99	99	99	99
Hardness difference (D – C)	37	37	44	19
Thickness (mm)	1.55	1.55	1.55	1.55
	(Golf ball)			
Flight performance				
Launch angle (degree)	12.8	12.9	12.4	12.5
Spin amount (rpm)	2690	2650	2850	2820
Carry (yard)	194.1	194.5	195.3	196.7
Shot feel	xWW	xW	xWW	xH

TABLE 8

	Comparative Example No. 5	6	7
	(Center)		
JIS-C hardness			
Central point hardness (A)	71	71	75
Surface hardness (B)	72	72	85
Hardness difference (B – A)	1	1	10
Diameter (mm)	36.4	36.4	36.4
	(Intermediate layer)		
Hardness (C) (JIS-C)	95	80	89
Hardness difference (B – C)	–23	–7	–4
Thickness (mm)	1.6	1.6	1.6
	(Outer layer)		
Hardness (D) (JIS-C)	99	99	95
Hardness difference (D – C)	4	19	6
Thickness (mm)	1.55	1.55	1.55
	(Golf ball)		
Flight performance			
Launch angle (degree)	12.45	12.4	12.6
Spin amount (rpm)	2830	2760	2800
Carry (yard)	196.3	196.5	195.3
Shot feel	xH	Δ	Δ

As is apparent from Tables 5 to 8, the multi-piece solid golf balls of Examples 1 to 8 had longer flight distance when hit by a driver and better shot feel than the conventional golf balls of Comparative Examples 1 to 7.

On the other hand, in the golf ball of Comparative Example 1, the deformation amount at the time of hitting is too large, and the flight distance is small, because the central point hardness of the center is low. In the golf ball of Comparative Example 2, the central point hardness of the center is too low, and the rebound characteristics are degraded, which reduces the flight distance, and the shot feel at the time of hitting is heavy and poor, because the difference between the surface hardness and the central point hardness of the center is large. In addition, since the hardness difference between the intermediate layer and the surface of the center is large, the golf ball does not deforms at all portion thereof, but it deforms only at a portion contacted with a club face of a golf club, and the contact area is large and the spin amount is large. Therefore the golf ball creates blow-up trajectory, which reduces the flight distance.

In the golf ball of Comparative Example 3, the contact area contacted with a club face of a golf club is large, and the spin amount is large and the golf ball creates blow-up trajectory, which reduces flight distance, because the hardness difference between the intermediate layer and the surface of the center is large. The shot feel is heavy and poor, because the hardness difference between the outer layer and the intermediate layer is large.

In the golf ball of Comparative Example 4, the shot feel is hard and poor, because the surface hardness of the center is large. In the golf ball of Comparative Example 5, the shot feel is hard and poor, because the hardness difference between the outer layer and the intermediate layer is small. In addition, since the hardness of the intermediate layer is higher than the surface hardness of the center, the hardness of an outer portion of the golf ball is high, and the deformation amount of the golf ball is small and the launch angle is small, which reduces the flight distance.

In the golf ball of Comparative Example 6, since the hardness of the intermediate layer is higher than the surface hardness of the center, the hardness of an outer portion of the golf ball is high, and the deformation amount of the golf ball is small and the launch angle is small, which reduces the flight distance. In the golf ball of Comparative Example 7, since the hardness of the intermediate layer is higher than the surface hardness of the center, the hardness of an outer portion of the golf ball is high, and the deformation amount of the golf ball is small and the launch angle is small, which reduces the flight distance. In addition, the shot feel is hard and poor, because the hardness difference between the outer layer and the intermediate layer is small.

What is claimed is:

1. A multi-piece solid golf ball comprising a center having at least one layer, an intermediate layer formed on the center, and an outer layer covering the intermediate layer, wherein the center has a JIS-C hardness of 65 to 85, a surface hardness of the center is higher than a central point hardness of the center by not more than 10, a JIS-C hardness of the intermediate layer is lower than the surface hardness of the center by 0 to 10, a JIS-C hardness of the outer layer is higher than the hardness of the intermediate layer by 15 to 40.

2. The golf ball according to claim 1, wherein the intermediate layer has a thickness of 1.0 to 1.8 mm, and the outer layer has a thickness of 1.5 to 2.3 mm.

3. The golf ball according to claim 1, wherein the center has a diameter of 34.5 to 37.5 mm.

4. The golf ball according to claim 1, wherein the center is formed a rubber composition, and the intermediate layer and the outer layer are formed from thermoplastic resin.

5. The golf ball according to claim 1, wherein the center has a JIS-C hardness of 65 to 80.

6. The golf ball according to claim 1, wherein the surface hardness of the center is higher than the central point hardness of the center by not more than 7.

7. The golf ball according to claim 1, wherein the JIS-C hardness of the intermediate layer is lower than the surface hardness of the center by 5 to 10.

8. The golf ball according to claim 1, wherein the JIS-C hardness of the outer layer is higher than the hardness of the intermediate layer by 19 to 37.

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